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A new species of *Unixenus* Jones, 1944 (Diplopoda, Polyxenidae) found in far north Queensland, Australia

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ABSTRACT

Unixenus Jones, 1944 (Polyxenidae) is the dominant genus of penicillate millipedes found throughout mainland Australia. Herein, a new species, *Unixenus mossmanus* sp. nov., is described from coastal forest near Mossman. The new species is similar to *U. karajinensis*, sharing the same sensilla pattern on antennal article VI and the same arrangement of leg setae. *Unixenus mossmanus* sp. nov. differs by having only 3 ornamental trichomes c per side (v. 5-9), 2 pairs coxal glands in the male (v. 6 pairs), and a slender claw (v. robust). These characteristics differ from those of *U. karajinensis*, which has 5–9 ornamental trichomes c; 6 pairs coxal glands in male; and a robust claw structure. 18S sequence of *Unixenus mossmanus* sp. nov. is included.

❑ *Diplopoda, Polyxenidae, Unixenus, Queensland, Australia.*

Unixenus Jones, 1944 (Polyxenidae) is a well-documented penicillate millipede genus found throughout mainland Australia (Short & Huynh 2011, 2013). The genus is characterised by having: 8 ommatidia on each eye; 13 pairs of legs; 8 antennal articles with VI longest and VIII shortest with 4 sensory cones; labrum surface with spherical papillae; tergal trichomes with two or more rows arranged in two latero-posterior clusters either side midline, with a central gap, anterior row often uneven, intermediate rows rarely in defined rows, and the posterior row of trichome sockets continuous or with a medial gap; and tarsus 2 with a slender seta. There are 13 previously described species worldwide: the type species *Unixenus padmanabhai* Jones, 1937 from India; *U. broelemanni* Condé & Jacquemin, 1962 from Madagascar; *U. vuillaumei* Condé & Terver, 1963 from the Ivory Coast; *U. intragramineus* Huynh & Veenstra, 2018c and *U. moniquea* Huynh & Veenstra, 2020 from Vietnam; and 8 Australian species: *U. mjoebergi* Verhoeff, 1924; *U. attemsi* Nguyen Duy-Jacquemin & Condé, 1967; *U. corticolus* Short & Huynh, 2011; *U. karajinensis* Short & Huynh, 2011; *U. barrabaensis* Short & Huynh, 2013; *U. carnarvonensis* Short & Huynh, 2013; *U. corringlensis* Short & Huynh, 2013 and *U. myallensis* Short & Huynh, 2013.

Herein we describe a new species of *Unixenus* from Far North Queensland, Australia. Little is known of these millipedes from Queensland, with the only species being *U. mjoebergi,* which is recorded from scattered coastal localities from them southeast to northeast of the state.

MATERIALS AND METHODS

Penicillate millipedes were collected from leaf litter by sieving and preserved in 90% ethanol. Further examinations were done in the laboratory as details below.

Morphometric study. Specimens were examined and measured using a SMZ 800 stereoscope with an Infinity I camera and an

Olympus CX41 compound microscope with a DP21 digital camera. Specimens were measured from head to telson, excluding the caudal bundle of trichomes. The sex of specimens was identified by the presence of sex organs on the coxal plates of the 2nd pair of legs. The specimens were prepared for taxonomic illustration following the staining and slide mounting technique of Short & Huynh (2010). This technique was used with modifications (included in the paragraph below) to permit the extraction of DNA for genetic studies. The remaining cuticles of the specimens were mounted on slides for morphometric analysis as described in Huynh & Veenstra (2015). Scanning electron microscopy (SEM) followed the technique of Huynh & Veenstra (2018b). The holotype and paratypes were deposited in the Queensland Museum (QMS), Brisbane, Australia.

Genetic study. The quantity of DNA extracted from six individual *Unixenus* specimens from Mossman (Queensland, Australia) was determined using a NanoDrop 1000 Spectrophotometer (ND 1000V3.60 software) following the manufacturer's instructions. The 18S gene was sequenced for this study. The 18S small subunit ribosomal RNA gene (primers 1F and 5R, White *et al*. 1990), has been used to elucidate relationships among arthropod groups including crustaceans, insects and myriapods (Turbeville *et al*. 1991, Luan *et al*. 2005, Wesener *et al*. 2010, 2016). This gene has also been used to help separate penicillate millipede species of the genera *Lophoturus*, *Monographis* and *Phryssonotus* in combination with morphological characters (Huynh & Veenstra 2015, 2018a, 2018b).

A representative DNA sequence from *Unixenus mossmanus* sp. nov. has been deposited in GenBank (http://www.ncbi.nlm.nih.gov), the following accession number for *Unixenus* sp. nov.: MT656009 (18S).

SYSTEMATICS

Subclass PENICILLATA Latreille, 1831

Order POLYXENIDA Verhoeff, 1934

Family POLYXENIDAE Lucas, 1840

Genus *Unixenus* Jones, 1944

Unixenus Jones, 1944: 94; Nguyen Duy-Jacquemin & Condé 1967: 68.

Type species. *Unixenus padmanabhai* (Jones 1937)

Genus diagnosis. as per (Huynh & Veenstra 2020)

Unixenus mossmanus sp. nov.
(Figs 1–4)

Material examined. HOLOTYPE : Subadult male, 12 pairs of legs (QMS 113000) collected from a roadside in coastal forest, Mossman, 16.385003 S, 145.416656 E, elevation 29 m, 11 km North northeast from the town centre of Mossman, Far North Queensland, Australia; on 10th December 2016, by C. Huynh. PARATYPES: QMS 113001 (paratype 1) subadult male, 12 pairs of legs; QMS 113002 (paratype 2) subadult male, 10 pairs of legs; QMS 113003–4 (paratypes 3 and 4), two females, adult – 13 pairs of legs; QMS 113005 (paratype 5) subadult female, 8 pairs of legs. Paratype collection data as for holotype male. All mounted slides to be catalogued and lodged in the Queensland Museum, Brisbane, Queensland, Australia.

Etymology. The species is named *Unixenus mossmanus* sp. nov. as this *Unixenus* species was first found in Mossman, Far North Queensland, Australia.

Diagnosis. Eye with 8 ommatidia, 13 pairs of legs; antennal article VI with a conical sensillum, 3 bacilliform sensilla arranged transversely and a setiform sensillum in anterior position; labrum with apical papillae; chaetotaxy with spined biarticulated setae; 3 ornamental trichomes ***c***, 2 pairs coxal glands; telotarsus slender, length of posterior lateral process equal to half length of claw and setiform process longer than claw.

Description. *Measurements* Holotype male (subadult 12 pairs of legs) 2.4 mm and caudal bundle 0.4 mm; paratypes: Adult females 2.9–3.0 mm, caudal bundle 0.5 mm, subadults 2.0 mm and caudal bundle 0.3 mm in both sexes.

Colouration. Head with two dark brown transverse bands on vertex connecting with

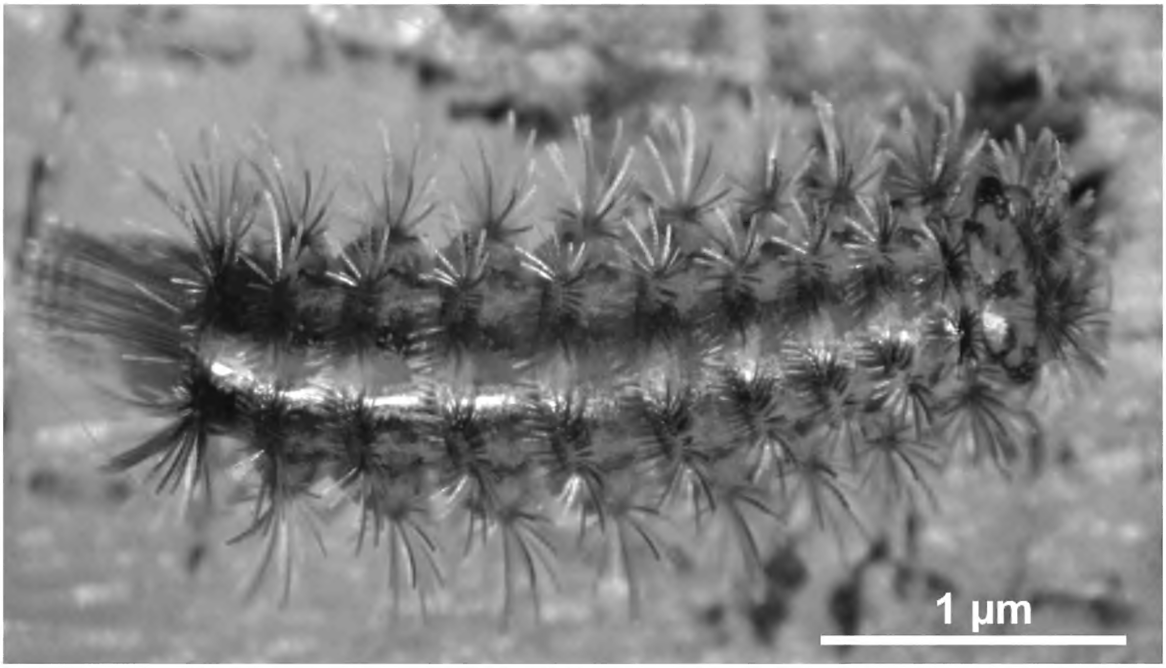

FIG. 1. Image of live *Unixenus mossmanus* sp. nov. (Polyxenidae).

dark brown eyes. Body light brown, contrasting with light silvery pleural trichomes and darker colour on caudal bundle; dark brown marks on latero-posterior rosette trichomes forming a dark band along each side of body laterally; darkest colour on last tergite (Fig. 1).

Head. Eye with 8 ommatidia: 4 dorsal, 4 lateral positions (1 anterior, 2 medial and 1 posterior position). Vertex with two posterior trichome groups, a large medial gap between these groups. Each posterior trichome group has 3 rows: anterior row short, with small trichome sockets, intermediate row longest, with larger trichome sockets arranged obliquely; posterior row short, with 5–6 large trichome sockets. Intermediate and posterior row separated by narrow space. Holotype's posterior trichome group with: anterior row with 8 sockets (Left: L) and 8 sockets (Right: R); intermediate rows with 14 sockets (L) and 13 sockets (R); posterior row with 6 sockets (L) and 5 sockets (R) (Figs. 2A, E, F) (Paratypes: adult females with: anterior rows 9–18 sockets, intermediate rows 12–15 sockets, posterior rows 7–10 sockets; all subadults with 3 clear rows each with fewer trichome sockets (Fig. 5A)). Trichobothria Typically thin sensory hairs with narrow cylindrical funicles; trichobothria equal in socket size forming an isosceles triangle with equal distance ab and bc (Figs. 2G, 5A) (trichobothrium a located in posterior position to head capsule, trichobothrium b in lateral position, trichobothrium c in anterior position). Antennae 8 antennal articles, 4 sensory cones, typical characteristics of Polyxenidae. Holotype: antennal article VI with 3 thick bacilliform sensilla, different lengths: anterior shortest, thick bacilliform sensillum (Ta), intermediate longest thick bacilliform sensillum (Ti), posterior sensillum long thick bacilliform (Tp); setiform sensillum (s) next to Ta, conical sensillum (c) next to Tp (Figs 3B, C; 6A, C). Antennal article VII with 2 thick bacilliform sensilla, Ta longer than Tp; setiform sensillum (s) between them and conical sensillum (c) next to Tp. (Figs. 3A, C; 6A, B). (Pattern of sensilla on antennal article VII common in *Unixenus*). Clypeolabrum Holotype with labrum bearing 10 setae along posterior margin, these setae less than half width of labrum (paratypes: 10–12 setae in both sexes). Labral surface with

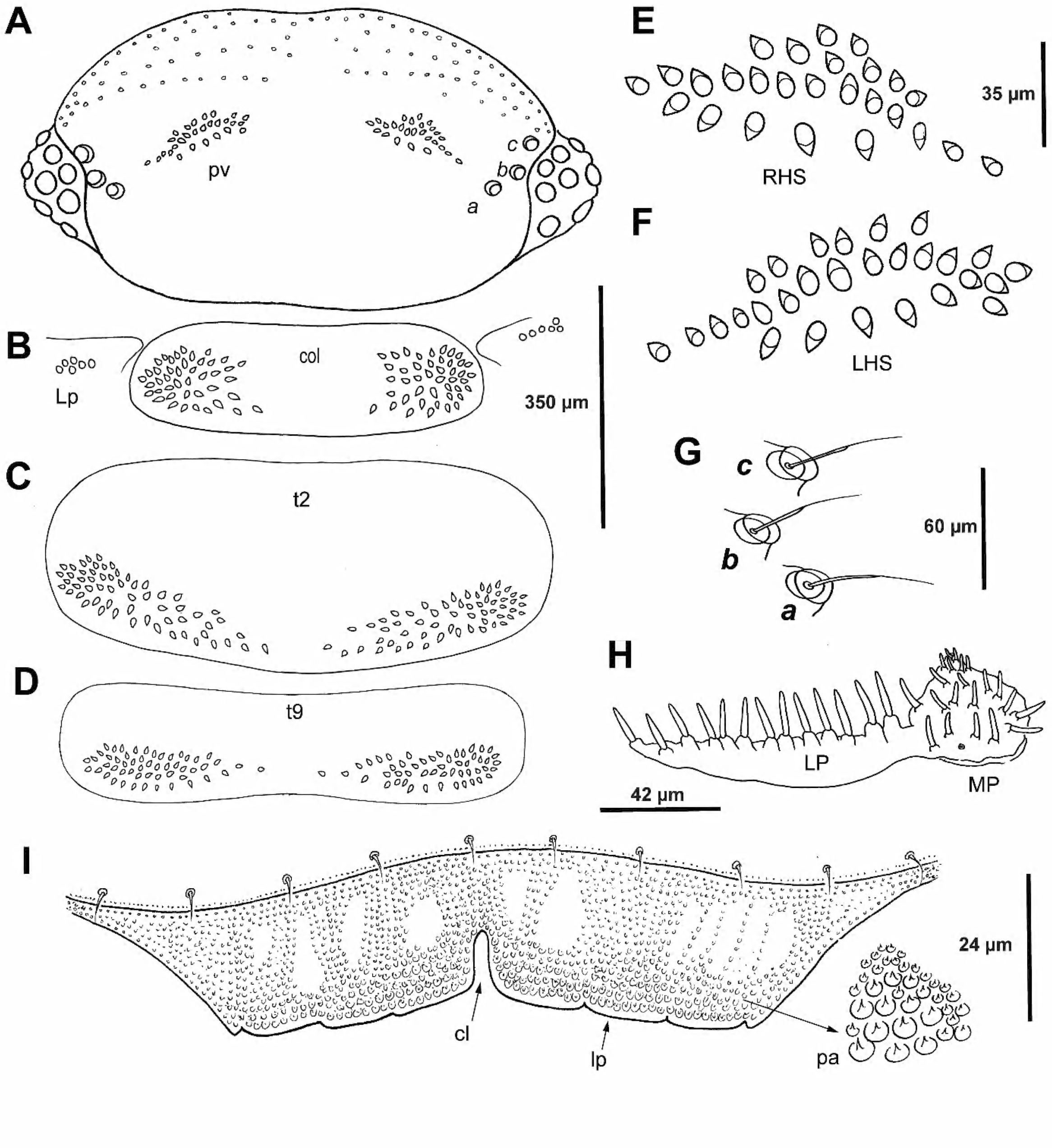

FIG. 2. Depiction of holotype male, *Unixenus mossmanus* sp. nov. **A,** Head capsule showing the posterior vertex trichome sockets (pv) and trichobothria (a, b and c); **B,** Collum (col) with trichome sockets patterns and the lateral protuberances (Lp); **C,** Tergite 2 (t2); **D,** Tergite 9 (t9); **E,** Posterior vertex trichome sockets (pv), right hand side (RHS), and **F,** Left hand side (LHS); G. Trichobothria: trichobothrium a (located posteriorly), trichobothrium b (located laterally) and trichobothrium c (located anteriorly); **H,** Gnathochilarium showing 2 parts: Lateral palp (LP) with 13 sensilla, medial palp (MP) with 22 sensilla; **I,** Labrum showing 4 linguiform processes (lp) on each side of the median cleft (cl) and the surface of labrum showing pointed end spherical papillate (pa).

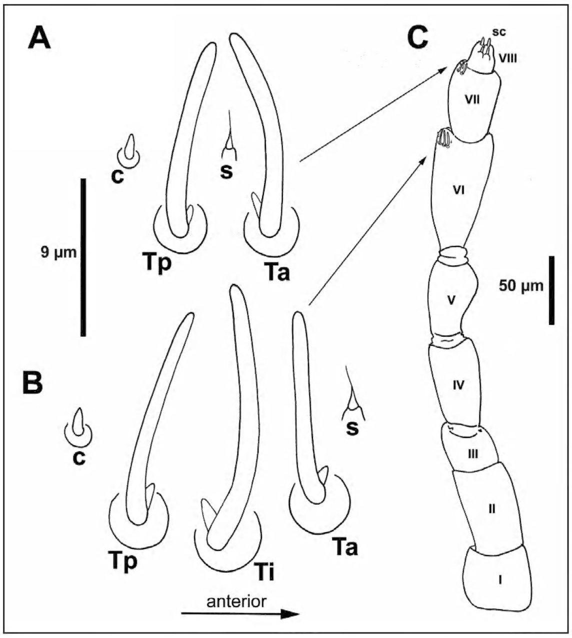

FIG. 3. Antennal articles and sensilla of the holotype male *Unixenus mossmanus* sp. nov. **A,** Arrangement of sensilla on the antennal article VII; **B,** Sensilla on the article VI; **C,** The left antenna showing 8 articles and the arrangement of sensilla on the antennal articles VI and VII. (c: conical sensillum, Ta: Thick bacilliform sensillum located in anterior position, Ti: Thick bacilliform sensillum located intermediately, Tp: Thick bacilliform sensillum in posterior position, s: setiform sensillum).

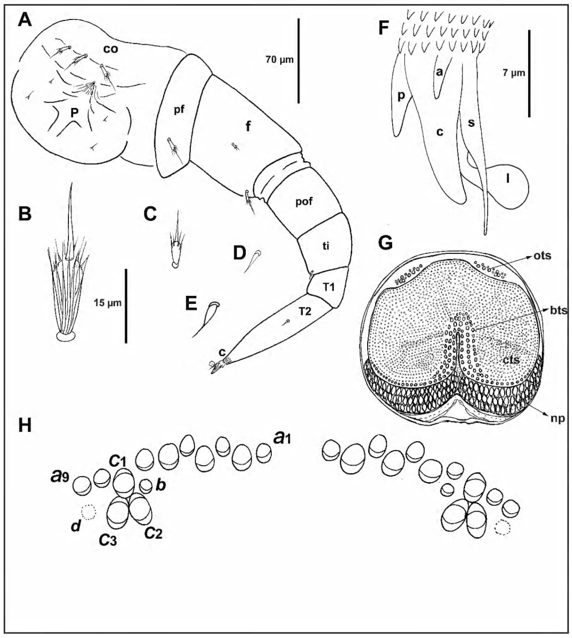

FIG. 4. Holotype male of *Unixenus mossmanus* sp. nov. **A,** The second left leg showing a penis (p), seven leg segments (co: coxa, pf: pre-femur, f: femur, pof: post-femur, ti: tibia, T1: tarsus 1, T2: tarsus 2), a claw and its chaetotaxy (setae on the leg segments); **B,** The large spined biarticulated, ridged funicular cylindrical sensilla presented on coxae, pre-femurs, the distal edge of the femurs and the posterior edge of the last sternite; **C,** A small version of B presented in the middle of femurs; **D,** A seta on tibiae; **E,** A slender seta on Tarsi 2; **F,** Telotarsus-claw showed all processes: Anterior lateral process (a), posterior lateral process (p), claw (c), the anterior setiform process (s) and the lamella process (l); **G,** The caudal bundle structure of the subadult showed 3 main parts (Dorsal – ventral): Ornamental trichome sockets (ots), caudal trichome sockets (cts) with the barbate trichome sockets (bts) in the centre, and the present of the new forming pleural projections (np); **H,** The ornamental trichome sockets, located dorsally on the caudal bundle structure, with 9 trichome a, 1 trichome b, 3 trichomes c and the circular indentation d.

apical papillae, each bearing setae, large along anterior margin, becoming smaller posteriorly. Anterior margin of labrum with lateral lamella and 3 lamellae on each side of median cleft (Figs 2I, 5D). Gnathochilarium: Lateral palp 2.5 times size medial palp. Lateral palp with 13 conical sensilla, medial palp with 22, same in holotype and paratypes (Figs 2H, 5B). Trunk: 10 tergites, 9 pleural projections, and telson excluding caudal bundle; 13 pairs of legs. Collum (tergite 1) with trichome sockets arranged in 2 oval shapes in lateral position pointed opposite each other, connected by posterior row of trichome sockets forming a line separated by large medial gap. Holotype, trichome sockets on collum with 43 on both sides, lateral protuberances (first pleural projections reduced in size) with 6 trichome sockets on each side (Fig. 2B) (Trichome sockets on collum varying in paratypes ranging from 46–60 sockets and 5 sockets on lateral protuberances in adult female; subadults: male (12 pairs of legs) with 42 sockets and 4 sockets). Tergites 2–10 each with pleural projections in anterolateral positions. Tergal trichome socket

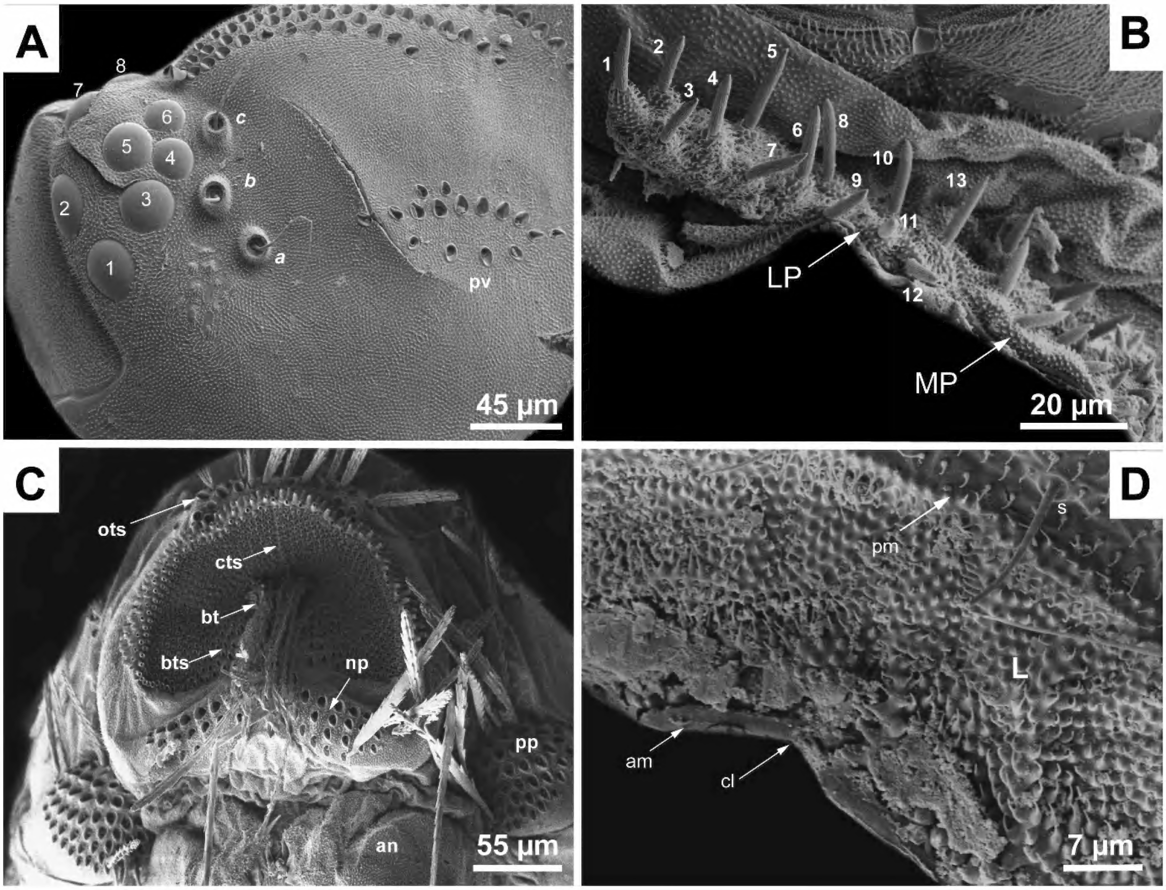

FIG. 5. SEM images of *Unixenus mossmanus* sp. nov. **A,** Dorsal view of the head capsule, left hand side, showing eye pattern with 8 ommatidia, trichobothria (a, b and c) and the posterior vertex trichome sockets (pv); **B,** Gnathochilarium: Lateral palp (LP) with 13 sensilla and the medial palp (MP) showing some sensilla; **C,** Telson structure showing the ornamental trichome sockets (ots), caudal trichome sockets (cts) and some barbate trichome sockets (bts), the newly formed pleural projections (np), the pleural projections (pp) and the anus (an); **D,** Labrum (L) showing the anterior margin (am) with the median cleft (cl) and the surface of labrum with pointed end spherical papillate, the posterior margin (pm) and a seta (s).

arrangements from tergites 2–8 typically with 2 thin oval shapes, slightly enlarged laterally, connected by posterior row extending toward to centre with large gap between these trichome sockets (Fig. 2C). Tergite 9 similar but with trichome sockets smaller and denser (Fig. 2D). Tergite 2 with 59 (L) and 58 (R) trichome sockets (Fig. 2C). Tergite 9 with 53 (L) and 52 (R) sockets (Fig. 2D) (In contrast, trichome sockets on tergite 2 in paratypes: Females 72–74, whereas tergite 10 with 58–64 trichome sockets; subadults with fewer sockets). Legs: Legs 1 and 2 without trochanter, leg 1 lacking tarsus 1. Chaetotaxy (setae on leg articles): Coxa 1: 1 seta, coxa 2: 2 setae, coxae 3–13: 2–3 setae; pre-femur and tibia with 1 seta; femur with 2 setae and tarsus 2 with 1 slender seta (Figs. 4A, 7A). Setae on coxa, pre-femur, femur with distal spines, ridged funicular cylindrical sensilla (Fig. 4B); setae on mid femur and tibia similar but smaller (Figs. 4C, 7A), tarsus 1 without seta, tarsus 2 with slender seta (Figs. 4A, E; 7A). Posterior edge of last sternite without seta in holotype (paratypes with 2–4 setae in adult). Sex

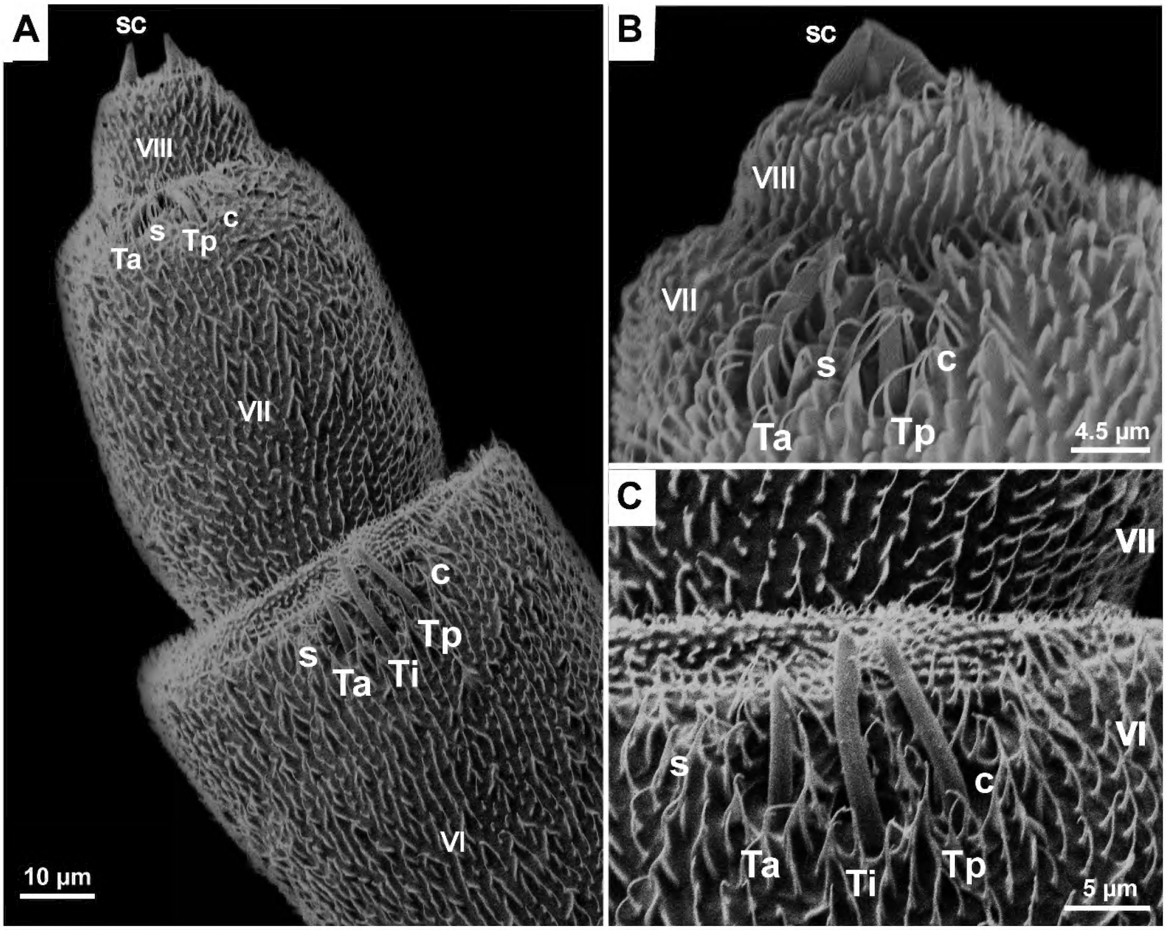

FIG. 6. SEM images of antennal articles VI – VIII of *Unixenus mossmanus* sp. nov. **A,** Antennal articles VI – VIII, sensory cones (sc) and the arrangement of sensilla; **B,** Antennal article VII with the sensilla, VIII and the sensory cones; **C,** Article VI with sensilla: A conical sensillum (c), the thick bacilliform sensilla (Tp: located in posterior position, Ti: located intermediately position, Ta: anterior position) and a setiform sensillum (s).

organs in male: Pair of penes present on coxa 2; 2 pairs of coxal glands on coxal plates of 8th and 9th legs. Telotarsus-Claw slender, bearing posterior lateral process equal to half length of claw. Small anterior lateral process and lamella process present, anterior setiform process slightly enlarged at base and longer than claw (Figs. 4F, 7B). Telson Dorsal ornamental trichome sockets arranged symmetrically on both sides of telson with 9 trichome a sockets in holotype (paratypes with 7–10 trichomes a), these trichome a sockets vary in size with small sockets and larger sockets forming transverse rows (Fig. 4H), single trichome b socket and 3 trichome c with large protruding base sockets: c1, c2 and c3, forming triangular shape each side of telson. Circular indentation d apparent near exterior side of trichomes c. Caudal bundles holotype male (subadult) with single bundle of uniform large trichome sockets of caudal trichomes, barbate trichome sockets in centre, and newly formed pleural projections located in ventral position of the bundle structure (Figs. 4G, 5C). Female, two obvious distinguishing structures: main dorsal structure similar to male, and 2 latero-sternal

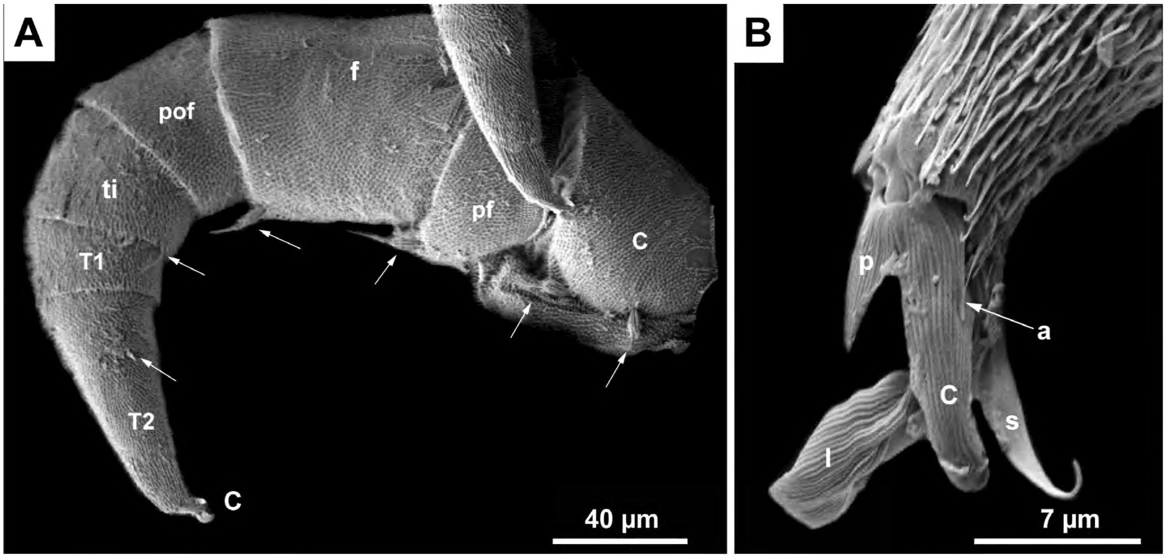

FIG. 7. SEM images of the leg segments and claw structure of *Unixenus mossmanus* sp. nov. **A,** The second leg (right hand side) without penis, showing its chaetotaxy (setae on the leg segments): Seven leg segments (c: coxa, pf: pre-femur, f: femur, pof: post-femur, ti: tibia, T1: tarsus 1, T2: tarsus 2) and a claw; **B,** Telotarsus-claw: Anterior lateral process (a), the posterior lateral process (p), claw (c), the setiform process (s) and the lamella (l).

bundles of smaller trichome sockets of nest trichomes. Caudal trichomes 2–4 hooks. (These caudal structures similar to Monographis (Huynh & Veenstra 2013) which are classified as caudal bundle type I (Condé & Nguyen Duy-Jacquemin 2008)).

Remarks. *Unixenus mossmanus* is similar to *U. karajinensis* by having has the same sensilla pattern on the antennal article VI and a similar arrangement of setae on the leg segments. *Unixenus karajinensis* has 5–9 ornamental trichomes ***c***, 6 pairs of coxal glands in the male, and a robust claw structure. In contrast, *Unixenus mossmanus* has only 3 ornamental trichomes ***c*** per side, 2 pairs of coxal glands, and a slender claw. In the key published by Huynh & Veenstra (2020), the new species comes to *U. karajinensis* and can be separated from it as per the differential diagnosis above.

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The vertebrate fossil collection record from the Chinchilla Sand, South-East Queensland, 1844–2021

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ABSTRACT

Since the mid-1840s a diverse fossil vertebrate assemblage, referred to as the Chinchilla Local Fauna, has been collected from the Pliocene deposits of the Chinchilla Sand on the western Darling Downs of South-East Queensland. In large part because of this long history and the numerous collectors who have worked fossil deposits in the area, much ambiguity regarding site and locality names and their specific coordinates exists. Here, we review the vertebrate fossil collection records in the Queensland Museum Fossil, Donor, Collector and Locality Registers, correspondence, and field notes in an effort to pinpoint the location of each named locality and site and develop a digital map which highlights the historical collecting sites at one significant locality in the Chinchilla area. To ensure that a systematic framework for all future collecting from the main collecting area (Chinchilla Rifle Range) is maintained, we recommend the use of consistent nomenclature for sites so that spatial information of the highest possible quality is captured into the future. We recommend future collections include detailed recordings of stratigraphic contexts as well as GPS coordinates.

❑ *Chinchilla Sand, Chinchilla Local Fauna, Pliocene, geoheritage, Australia, Darling Downs*

The Darling Downs is a fertile agricultural region in South-East Queensland extending west of Brisbane from the Great Dividing Range to the Condamine River and its catchments. The earliest-known Indigenous occupation of the region dates to the late Pleistocene (Gill 1978). European settlers began to select land in the region from the early 1840s, seeing the potential for agricultural development, and early correspondence, diaries and newspaper articles report frequent fossil discoveries. Explorer, naturalist and keen fossil collector, Ludwig Leichhardt, mentions fossil collections from the Darling Downs in a letter to Sir Richard Owen, on 10 July 1844, *"the collection of fossil bones I made in Darling Downs...'* (Leichhardt 1844). In 1875 an article in a Brisbane newspaper, reporting on recent additions to the Queensland Museum collection, mentions, "*Some excellent fossils have also been received, prominent among which are part of the upper jaw of the extinct Diprotodon*" (Anon 1875). Many of these fossils made their way to Brisbane or Sydney for identification, but with limited local expertise they were subsequently sent to experts in England, such as anatomist and palaeontologist Sir Richard Owen, for identification and study.

The latter half of the 1800s was a time of great expansion in scientific knowledge all over the Commonwealth, with collection and donation of specimens to fledgling museums

by the public becoming commonplace. In 1862, the Queensland Museum was established and palaeontologist Charles de Vis committed himself to developing a thorough understanding of the Darling Downs fossils. Early Museum palaeontologists and collectors began to differentiate between the collections from the eastern Darling Downs, being exclusively Pleistocene, and those from the western Darling Downs including Chinchilla (Mackness and Godthelp 2001; Price 2012). Thus began the collection history of fossils from the Chinchilla area, which continues to the present day.

Localities with long collection histories often present curatorial challenges where documentation is vague, incomplete, or even incorrect, which can lead to confusion for museum staff and researchers. Many Chinchilla fossils collected in the 19th Century lacked clear collection data, and on some occasions, material collected from surrounding areas, packed and transported to Brisbane from Chinchilla, was labelled 'Chinchilla', adding to the confusion (Mackness & Godthelp 2001). Similar challenges were experienced at other museums such as the early records of fossil collections from Wellington Caves at the Australian Museum (Dawson 1985). While consistency is certainly the aim, changes in museum staff over time, changes in collection and curatorial practice and a variation in the approaches used in the documentation of sites can lead to inconsistencies in recording important information, resulting in the loss of both site-specific and fossil-specific details. Invariably the quality of data available has improved over time with access to geo-reference information from printed and digital sources and modern technologies.

Here we examine 150 years of vertebrate fossil collection history from the Chinchilla Sand, a geological formation that has yielded Australia's largest, richest, and best-preserved vertebrate Pliocene assemblage (Cook 2012). This assemblage is referred to as the Chinchilla Local Fauna and is represented by at least 63 fossil taxa in 31 families (Louys & Price 2015). A significant proportion of the Pliocene vertebrate fossils (hereafter fossils) currently housed in the Queensland Museum Geosciences Collection are from this formation and in particular a locality known as the Chinchilla Rifle Range. Our aim is to develop a clear understanding of locality and site names in the Chinchilla Sand and explore the possibility of establishing provenance of historically collected material with confidence. This project, a joint collaboration between the Queensland Museum, the Samford Valley Steiner School, Griffith University and the University of Queensland, aimed to establish a detailed digital map highlighting key sites and landmarks of the main gully system at the Chinchilla Rifle Range, referred to as 'Middle Gully system' (Bartholomai, 1966). The map brings together all known sites in the vicinity of Middle Gully system into a digital format. The integration of historical and cartographical data will help ensure more accurate collecting and documentation of the site into the future.

HISTORICAL AND GEOGRAPHICAL CONTEXT

The Chinchilla Sand is located on the western Darling Downs in the Condamine River system of South-East Queensland (Fig. 1), and lies on the traditional lands of the Burunggum people. In January 1846 European settler Matthew Buscall Goggs was the first to apply for a depasturing license on the lower Condamine. His lease included the current Chinchilla township, Branch Creek to the north, parts of Charleys Creek, a portion of the Condamine River and the land where the Chinchilla Rifle Range is situated today (Truscott 2004). Goggs' property remained unnamed until 1847 when it was called 'Lower Condamine', then in 1848 it was renamed 'Chinchilla Station' (Mathews 2004). The Chinchilla Post Office opened on 3 January 1878 and with this came the birth of the township of Chinchilla. It is worth noting that for a period of 30 years, between 1848 and 1878, fossils with associated locality data using the word 'Chinchilla' would have referred to 'Chinchilla Station', and not necessarily to the township of Chinchilla.

The Chinchilla Sand is a formally defined Pliocene sequence that consists of inter-bedded fluvial and alluvial clays, sands, and

conglomerates (Woods 1960), many of which contain abundant fossils with an estimated age inferred by faunal correlation of 3.6 Ma (Louys & Price 2015). Fossil bearing Quaternary sediments, probably Pleistocene in age, surround the Chinchilla Sand in all directions and a small amount overlies the northern part of the sequence near the Chinchilla township (Fig. 1A). A small number of fossil specimens collected in likely Quaternary deposits to the north and north-west of the mapped Chinchilla Sand at 'Fairymeadow', Charleys Creek, 'Seven Oaks' and 'Tralee' appeared in our search but without stratigraphic context we cannot verify these as Pliocene.

Within the Chinchilla Sand one important locality, known as the Chinchilla Rifle Range, deserves attention for its abundance of fossils and continuous collection history. The Chinchilla Rifle Range, a highly significant geoheritage site (Percival 2014; Australian Heritage Council 2012), lies within the Chinchilla Sand Local Fossil Fauna Site, defined in the Australian Heritage Database Register of National Estate (non-statutory archive) (Anon 2020) as approximately 120 hectares of State-owned land, 3 kms south-east of Chinchilla, extending from the Warrego Highway to the Condamine River (Fig. 1). This locality is the last remaining example of the Chinchilla Sand with an intact profile and includes the type section described by Jack Woods (Woods 1960) on the banks of the Condamine River (Fig. 2).

Not only recognised as an important palaeontological site, this locality is also recognised for its geological, botanical, zoological, cultural, and historical importance. The native vegetation is one of the few remaining sizeable examples of original Brigalow vegetation (open forest dominated by the brigalow tree, *Acacia harpophylla*) associated with the Condamine River, and in 2002, the land was declared a 'Nature Refuge' under the Nature Conservation (Protected Areas) Regulation 1994. A rifle range was established on the land in 1912, and as part of the Nature Conservation Agreement a lease agreement was established with the Sporting Shooters Association of Australia (SSAA), Chinchilla Branch. Access to the locality is therefore strictly regulated by the SSAA for safety reasons and the SSAA will only consider requests to undertake research on the sites from recognised scientific institutions, or those working under their auspices.

MATERIALS AND METHODS

Queensland Museum records and data collaboration

Queensland Museum records used in our review include Donor Registers No.1 (1875-1881), Donor Register No. 2 (1882-1887), Donor Register No.3 (1899-1909), Donor Register No. 4 (1899-1909), Donor Register No. 5 (1910), Extended Donor Register (1885 – 1888), Extended Donor Register (1887-1910), QM 'Old' Collection Register C1-C178 (1884-1899), QM Donors Schedule (1911-1946), QM Library Inward Correspondence Registration records, QM Library archives (Kendall Broadbent field diaries 1886-1889), Cecil (hereafter Cec) and Doris Wilkinson's collection records (hereafter Wilkinson Collection Register) and the QM Collection Management System (hereafter QM CMS) which includes digital records of the QM Fossil Register (hereafter QMF), and the QM Locality Register (hereafter QML) which are still actively in use.

Newspaper records accessed via online research portal, TROVE, were also utilised and clarification of some data was established via personal communications with key collectors, researchers, and donors. These included Jack Woods (QM Director 1964-1968), Alan Bartholomai (QM Curator, Director 1969-1999), Michael Archer (QM Curator 1972-1978), Henk Godthelp (QM Palaeontologist 1976-1979, 1981-1982), Ralph Molnar (QM Curator 1978-2000) and local Chinchilla fossil collectors and QM Honorary Officers, Cec and Doris Wilkinson.

The fossil collection history presented in Table 1 is divided into 6 collection phases and includes a complete list of collectors, data source, and a data accuracy rating with an increase in accuracy over time clearly discernable. Low levels of

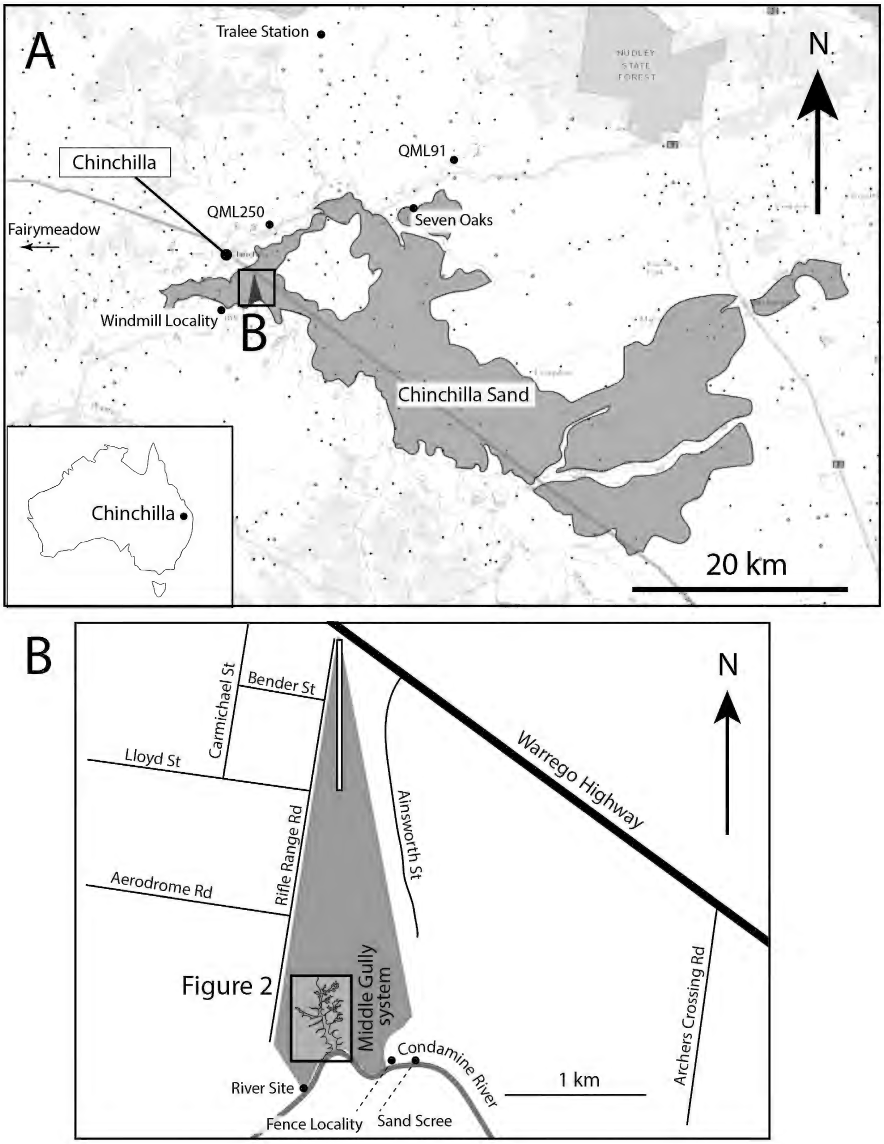

FIG. 1. Study region. A, Location of Chinchilla on the western Darling Downs, the Chinchilla Sand, the Chinchilla Sand Local Fossil Fauna Site (including Chinchilla Rifle Range) and vertebrate fossil localities mentioned in the text; B, Map showing Chinchilla Sand Local Fossil Fauna site (including Chinchilla Rifle Range), location of Middle Gully system and vertebrate fossil localities.

data accuracy include general descriptions of local features or township names which rarely allow for relocation of the original collection sites. Medium accuracy data includes map co-ordinates and specific descriptions of local features, such as the rivers and creeks, or descriptions of specific gullies and ridges which may make relocation possible in certain circumstances. High accuracy includes map references and digital technology records, such as GPS (Global Positioning System), leading to confident relocation of original

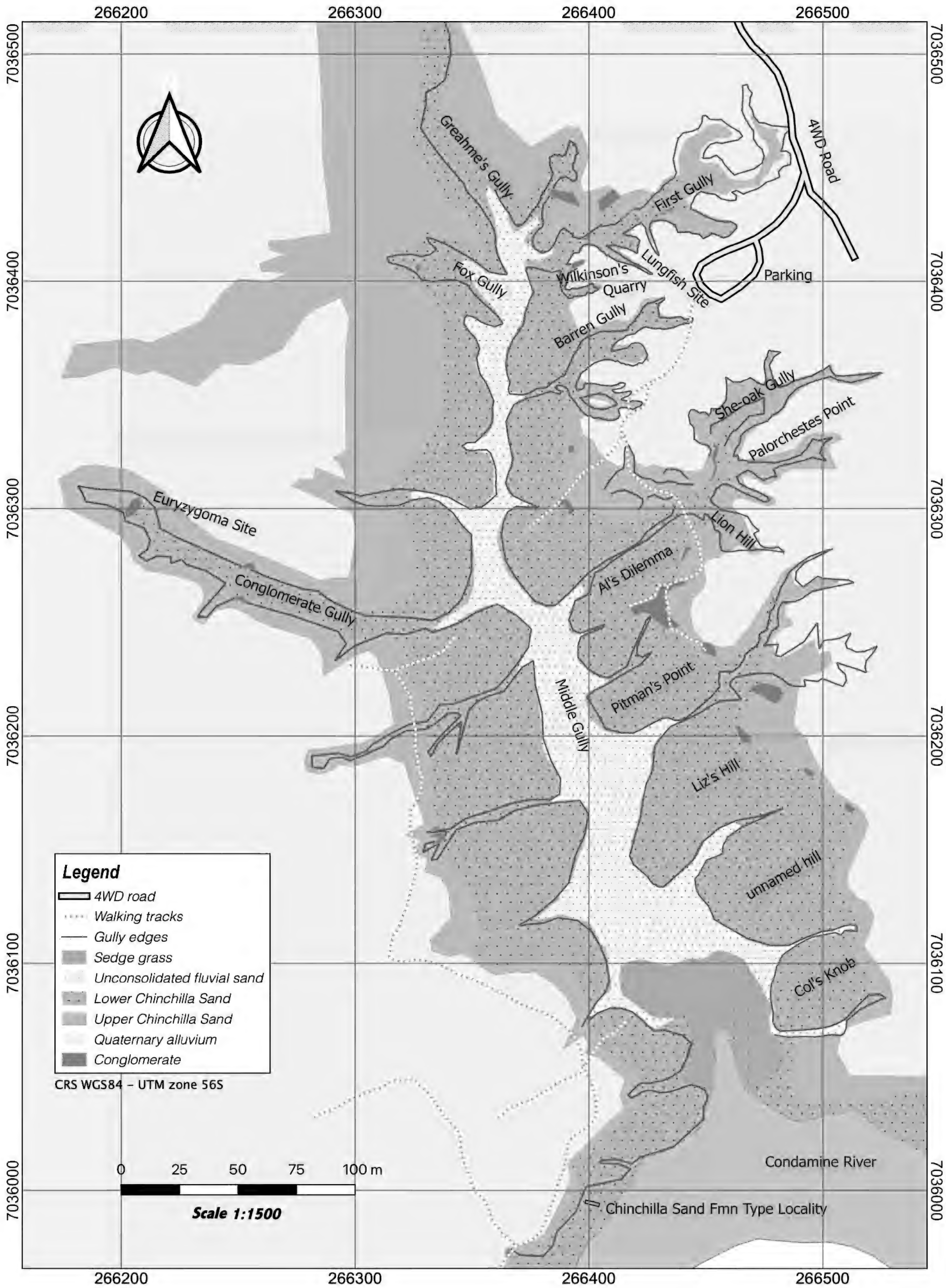

FIG. 2. Digital map of Chinchilla Rifle Range site showing Middle Gully system and site names.

TABLE 1. Collection phases 1-6. *QM Staff; Abbreviations: QM CMS-Queensland Museum Central Management System (Vernon); Low – township or area name and description of local features; Medium - map references; High - GPS data.

Collector	Data Source	Accuracy
Phase 1 1875-1914		
Mr Juric	QM Donor Register 1875-1881. Entry date; 4 May, 1878	Low
Peter Clark	QM Donor Register 1882-1887. Entry date; March 1883, No.506	Low
*Kendall Broadbent	QM CMS; QM Donor Register 1882-1887 Donor Number 4205; QM Collection Register 1884-1899, Collection Numbers 14, 21, 69, 106, 107, 133, 139, 151, and 171; QM Library Inward Correspondence Registration Numbers 281, 334, 508, 509, 526, 527, 537, 560, 2015, 2036, 2055 and 2080. Field diaries 1886-1889 in QM Libaray Archives.	Medium
*Henry Hurst	CMS; QM Library Inward Correspondence Registration Numbers 2242, 2254, 2266 and 2298	Low
*Alexander MacPherson	QM CMS; QM Library Inward Correspondence Registration Numbers 280 and 379	Low
*Henry Tryon	QM Library Inward Correspondence Registratiion Number 315	Low
*Patrick Wall	QM Library Inward Correspondence Registration Number 2242. (Wall is mentioned in correspondence from Hurst to deVis)	Low
Leslie Corrie	QM Donors Schedule. Entry Date; 4 May, 1912	Low
Benjamin Dunstan	QM CMS	Low
Phase 2 1915-1950		
C. Bishop	QM CMS	Low
A. Bishop	QM CMS	Low
G. Kleidon	QM CMS	Medium
Phase 3 1951 - 1970		
M. McEnna	QM CMS	Low
Stirton,Marcus & Woodward expedition	QM CMS	Low
*Jack Woods	QM CMS	Medium
*Alan Bartholomai	QM CMS	Medium
W. Dunmall	QM CMS	Low
R. Olsen	QM CMS	Low
K. Kerr	QM CMS	Low
Malcom and Marjorie Wilson	QM CMS	Low
F. Nothdraft	QM CMS	Medium
R. Lowardon	QM CMS	Low
K. Emmerson	QM CMS	Medium
M. Schuster	QM CMS	Low
Phase 4 1971-1980		
*Alan Bartholomai	QM CMS	Medium

TABLE 1 cont…

Collector	Data Source	Accuracy
*Michael Archer	QM CMS, M. Archer field notes, 1973-1974	Medium
*Jeanette Covacovich	QM CMS, M. Archer field notes, 1973-1974	Medium
Hendrick (Henk) Godthelp	QM CMS	Medium
Malcolm & Marjorie Wilson	QM CMS	Medium
*Roland Mackay	QM CMS	Medium
Kelvin Grove Teachers College	QM CMS, M. Archer field notes, 1973-1974	Medium
Bernard Cooke	QM CMS, M. Archer field notes, 1973-1974	Medium
P. Pitman	QM CMS, M. Archer field notes, 1973-1974	Medium
Col Limpus	QM CMS, M. Archer field notes, 1973-1974	Medium
D. Archibald	QM CMS	Low
D. Worthington	QM CMS	Medium
Phase 5 1981 - 2000		
*Alan Bartholomai	QM CMS	Medium
Joan Wiffen	QM CMS	Medium
D. Worthington	QM CMS	Medium
E. Yansen & party	QM CMS	Medium
*Tempe Lees	QM CMS	Medium
C & D Wilkinson	QM CMS	High
*Laurie Beirne	QM CMS	High
Chris Cameron	QM CMS	Medium
Mrs Bennett	QM CMS	Low
*Ralph Molnar	QM CMS	High
*Paul Stumkat	QM CMS	High
*Joanne Wilkinson	QM CMS	High
Brian Mackness	QM CMS	High
Mrs Austin	QM CMS	High
M. Wilkinson	QM CMS	High
Malcolm & Marjorie Wilson	QM CMS	Medium
Jewel Pozefsky	QM CMS	Low
John Eustice	QM CMS	Low
Paul McKenzie	QM CMS	Medium
Robert Knezour	QM CMS	High
*Scott Hocknull	QM CMS	High

TABLE 1 cont…

Collector	Data Source	Accuracy
Phase 6 2000-2020		
C. & D. Wilkinson	QM CMS	High
A. Bishop	QM CMS	Low
John Eustice	QM CMS	High
Malcolm and Marjorie Wilson	QM CMS	Medium
Ian Sobbe	QM Reserve Collection	High
Geoff and Dorothy Vincent	QM CMS, QM Reserve Collection	Low
Gilbert Price	QM Reserve Collection	High
Julien Louys	QM CMS, QM Reserve Collection	High
Kenny Travouillon	QM Reserve Collection	High
*Mary Wade	QM Reserve Collection	High
*Peter Jell	QM Reserve Collection	High
*Alex Cook	QM Reserve Collection	High
*Andrew Rozefelds	QM Reserve Collection	High
*Scott Hocknull	QM CMS, QM Reserve Collection	High
*Kristen Spring	QM Reserve Collection	High
*Joanne Wilkinson	QM CMS, QM Reserve Collectin	High
*Rochelle Lawrence	QM Reserve Collection	High
*Christina Chiotakis	QM Reserve Collection	High

collection sites. Fossil material collected by QM staff in Phase 6 is incorporated into either the QM Reserve Collections or registered as part of the QM State Research Collection.

A complete list of site and locality names from the Chinchilla Sand was compiled using the QM CMS based on locality, collection, and acquisition field parameters, as well as existing field notes, diaries, correspondence, publications, and the Wilkinson Collection Register. This list is presented in Table 2 and while these sites and locality names were not commonly cited in research publications, they are useful when collating data coupled with field maps and field notes. It should be noted that there are two different, but equally correct, ways in which numbers may be allocated in the QML system. An individual number may represent a site/locality, or alternatively, may represent a single collecting event, depending on which is more appropriate for the fieldwork project. Collection trips to Chinchilla Rifle Range between 1964 and 1982 with allocated numbers QML7, QML237, QML238, QML239, QML242, QML243, QML247, QML248, QML249, QML298, QML299, QML300, QML303, QML304, QML308, QMF357, QML437 and QML438 relate to single collection events and do not represent a site-specific location, so they do not appear on figures 1 or 2.

A literature search identified two published sites from the Chinchilla Rifle Range, 'Middle Gully system', first published by Alan Bartholomai (Bartholomai 1966), and 'Wilkinson's Quarry', first published by Brian Mackness *et al.* (2000). Some sites are known

by more than one name and these appear as synonyms in Table 2, with published names or names appearing in acknowledged registers or field notes taking precedence.

The ability to link early sites and localities to collectors strengthens the ability to pinpoint where specimens were collected prior to the use of modern methods, such as GPS and photogrammetry. Cec and Doris Wilkinson provided a detailed locality map linking many of the site names to the Wilkinson Collection Register, and in 2014 accompanied two of the authors to the Chinchilla Rifle Range to undertake a GPS survey where each site was located, carefully examined, and recorded. The final step was to establish a map of the Middle Gully system, incorporating this data.

Map production and interpretation. A series of four annual surveying camps, from 2014–2017, involving students and staff from several Steiner schools, collected data to produce a digital map of Middle Gully system at the Chinchilla Rifle Range (Fig. 2). A triangulation grid of approximately 4000 m^2 was laid out over four overlapping sections of the map area with all angles measured at each grid point. A 'baseline' measurement was chosen from a single side in the triangulation grid and used to calculate all grid side lengths with the sine rule and the previously measured grid angles. The Universal Transverse Mercator (UTM) Coordinate Reference System (CRS) was used for both surveying and mapping. The UTM location of the grid point at each end of the baseline was determined using GPS averaging using a Garmin GPSmap62S. Some basic surface geology including outcrops of conglomerate, alluvial sand, and changes in sediments higher up in gully profiles were noted by the surveying students. The map legend includes unconsolidated fluvial sand, lower Chinchilla Sand, upper Chinchilla Sand, Quaternary alluvium, and conglomerate. The authors acknowledge that the terms "lower Chinchilla Sand" and "upper Chinchilla Sand" are not officially recognised geological terms but represent observed changes in sediments, and that further stratigraphic studies are required. The mapping and geographic information system software QGIS (https://qgis.org/en/site/) was used to prepare the map of the Chinchilla Rifle Range site showing Middle Gully system.

RESULTS

Collection History

Phase 1: 1844-1914 Early Collectors. Evidence of fossil collection from the general Darling Downs region, prior to the establishment of the Queensland Museum in 1862, can be found in diaries, correspondence, and newspaper articles. Explorer, naturalist and keen fossil collector Ludwig Leichhardt writes in his diary on 9 April 1844, *"I began my journey over the Downs with the object of visiting those places in which fossil bones had been found."* (Leichhardt 1844). Even though it is clear that Leichhardt collected fossils from the Darling Downs (Fensham & Price 2013), there is no evidence that those specimens were ever accessioned into the collections of the QM. His correspondence to Owen (Leichhardt 1844) suggests his collections were sent to Richard Owen, in England, for identification. The first fossil record from Chinchilla appears in the QM Donor Register (1882-1887) on 4 May 1878, donated by Mr Juric. The entry simply states 'fossil bones from Chinchilla' with no other details and unfortunately was typical of many such donations at the time. In 1882 Charles de Vis began his career as Curator (1882-1901) and later Director (1901-1905) at QM and arranged employment of collectors, clerical assistants, and assistant curators including Kendall Broadbent, Henry Hurst, Henry Stokes, Alexander MacPherson, Charles Wild, Henry Tryon and Patrick Wall to carry out a variety of museum tasks, including travelling throughout Queensland in search of items of interest to build the State Collection. Henry Hurst wrote to Charles de Vis from the fossil-rich banks of the Condamine River at Chinchilla on the 26 November 1887 reporting that he and Patrick Wall were returning to Brisbane with "*nearly 3,000 specimens*" collected in 70 days and that they had "*nearly worked out this locality*" (Hurst 1887). This letter was typical of frequent correspondence from collectors to de Vis which often included information about their

TABLE 2. Verified sites and localities from the Chinchilla Sand. Abbreviations: QM CMS - Queensland Museum Collection Management System (Vernon).

Site/Locality name *Synonym*	**QML Registration No.**	**Data Source**	**Comments**
Al's Dilemma	QML332	M. Archer field notes (1973-1974)	Chinchilla Rifle Range (Fig. 2).
Barren Gully		C. & D. Wilkinson Collection Register	Chinchilla Rifle Range (Fig. 2).
Chinchilla Sand Type Section locality	QML110, QML296, QML301 QML302 QML309 QML310	J. Woods (Woods, 1960), Alan Bartholomai QM CMS	Chinchilla Rifle Range (Fig. 2).
Col's Knob	QML294, QML307	M. Archer field notes (1973-1974)	Chinchilla Rifle Range (Fig. 2).
Conglomerate Gully		J. Wilkinson, G. Price, J. Louys field notes (2015)	Chinchilla Rifle Range (Fig. 2). Extensive conglomerate layers outcrop at this site.
Euryzygoma Site		J. Wilkinson, G. Price, J. Louys, field notes (2015)	Chinchilla Rifle Range (Fig. 2).
Fence Locality		M. Archer field notes (1973-1974)	Chinchilla Rifle Range (Fig. 1B).
First Gully		C. & D. Wilkinson Collection Register	Chinchilla Rifle Range (Fig. 2). North of circular car park and often the first gully to be explored.
Fox Gully		C. & D. Wilkinson Collection Register	Chinchilla Rifle Range (Fig. 2)
Greahme's Gully *Grey's Gully*		C. & D. Wilkinson Collection Register	Chinchilla Rifle Range (Fig. 2). Named in memory of Cec and Doris Wilkinson's son, Greahme Wilkinson. (Spelling confirmed pers. comm. Cec Wilkinson to JW 14 April 2016)
Intruder's Knob *Intruder's Site*		C. & D. Wilkinson Collection Register	Chinchilla Rifle Range (Fig. 2). Where discarded fossil material from intruders was found by Cec and Doris Wilkinson.
Lion Hill		C. & D. Wilkinson Collection Register	Chinchilla Rifle Range (Fig. 2). Named for its unusual abundance of thylacoleonid fragments in 1990's. (Pers. Com. Cec Wilkinson to JW 23 July 2016)
Liz's Hill	QML295 QML306 QML355	M. Archer field notes (1973-1974)	Chinchilla Rifle Range (Fig. 2).
Lungfish Site		C. & D. Wilkinson Collection Register	Chinchilla Rifle Range (Fig. 2). Lungfish toothplates have been found at this site.
Middle Gully system *Middle Gully* *Main Gully system* *Main Gully*	QML2, QML3, QML4, QML5, QML6, QML8, QML111, QML94, QML233, QML234, QML237, QML356	A. Bartholomai QM CMS	Chinchilla Rifle Range (Fig. 2). Both western and eastern gully systems drain into the main gully system which flows into the Condamine River. Alan Bartholomai named the Chinchilla Rifle Range main gully system, Middle Gully system and first published in 1966 (Bartholomai, 1966).

TABLE 2 cont…

Site/Locality name *Synonym*	**QML Registration No.**	**Data Source**	**Comments**
Palorchestes Point		J. Wilkinson, K. Spring field notes (2016)	Chinchilla Rifle Range (Fig. 2).
Pittman's Point	QML331	M. Archer field notes (1973-1974)	Chinchilla Rifle Range (Fig. 2).
River Site *River Shore* *River Terrace*		C. & D. Wilkinson Collection Register	Located on the Condamine River bank 200m downstream of Chinchilla Sand Fmn Type Locality (FIG 1B). (Location confirmed pers. comm. Cec Wilkinson to JW 23 July 2016.)
Sand Scree Locality	QML1, QML95 QML235 QML236, QML354	A. Bartholomai QM CMS	Chinchilla Rifle Range (Fig. 1B).
She-oak Gully		C. & D. Wilkinson Collection Register	Chinchilla Rifle Range (Fig. 2).
Site 1		C. & D. Wilkinson Collection Register and site map	Next to Wilkinson Quarry (Fig. 2).
Wilkinson's Quarry *Dig Site* *Cec & Doris Quarry*		C. & D. Wilkinson Collection Register	Chinchilla Rifle Range (Fig. 2). First published by Mackness et. al. in 2000 (Mackness, Rowe, Muirhead, Wilkinson and Wilkinson, 2000).
Windmill Locality	QML92, QML93, QML297 QML305	M. Archer field notes (1973-1974)	Junction of Windmill Road and the Condamine River (Fig. 1A).

whereabouts, lists of items collected, estimated times of shipments to Brisbane, requests for additional supplies, such as bullets, return train tickets and sometimes salary advances. Information from correspondence and field diaries was transferred to the Collection and Donor Registers when material was accessioned upon return. Kendall Broadbent in particular kept meticulous field diaries, located in the QM Library archives, containing descriptions of local features describing collection sites on the Condamine River and Charleys Creek, but with over 100 years passing these sites are difficult to accurately pinpoint today.

During this phase QM record systems included Collector and Donor Registers using sequential number systems, dates, collector and donor names, addresses, and item descriptions. This was an improvement on earlier data capture, but general locality names like 'Chinchilla' were still common. Fossil material designated by QM collectors in the late 1800s was designated a series of 'C' numbers and many appear in the 'old' Collection Registers as bulk collections. The earliest 'C' number from Chinchilla is 'C14' representing fossils collected by Kendall Broadbent in May 1885 from Chinchilla.

A QM Donor Schedule system introduced in 1911 included an identification sheet, adding more value to the data. An entry on 4 May 1912, recording the donation of the right mandible of a *Nototherium* collected from Chinchilla by Mr Leslie Corrie of Brisbane, shows advancements in identification fields but detailed site information remained lacking.

The establishment of the Chinchilla Rifle Club in 1908 was an important milestone in the history of the fossil collection story of Chinchilla. The club began operations from the original range located west of Chinchilla, most likely near the Golf Club or Rocky Creek area (pers. comm. John Dennis to JW 15 March, 2015), then relocated to the current site, 3 kms east of Chinchilla, around 1912. Today the club

operates as a branch of the SSAA. Scientific collection and research have taken place almost continuously since these early days, so location data for fossils collected from this locality remain broadly accurate.

Phase 2: 1915-1950. The War Years and Depression. This phase was dominated by the effects of the First and Second World Wars and the Great Depression. During this time QM staffing levels were reduced, the museum focused on maintenance, not growth of the collection and while some research continued, there were no funds available for fieldwork, (Mather 1986). Only two donations from Chinchilla were recorded, a *Vombatus* fragment, QMF43548, collected in March 1936 by Mrs C. Bishop providing general locality information 'Chinchilla', and a *Troposodon* jaw fragment with two molars, QMF42631, collected by Mrs A. Bishop with locality recorded as 'Chinchilla SEQ'. Additionally, more than 70 fragments of an individual skull later referred to the giant wombat-like marsupial, *Euryzygoma*, were donated to the QM having been collected from Brigalow, approximately 20 km southeast of Chinchilla. The fossils (QMF1327) were collected at a depth of around 21 m following the sinking of a well on the property of Mr G.A.F. Kleidon. Although Longman (Longman 1921) considered the specimen to be 'Post-Tertiary' (i.e. Quaternary), *Euryzygoma* is reliably known only from Pliocene deposits (Price & Piper 2009) hence the specimen was likely derived from the Chinchilla Sand.

Phase 3: 1951-1970. The Developing Museum. Interest from researchers increased in the 1950s, and this was particularly stimulated by visiting international palaeontologists from the USA such as Ruben A. Stirton in 1954, and Dick Tedford in 1955. Collection data from Stirton's trip is accurate for its time as shown by entry QMF6141, a *Euryzygoma,* collected on 1 January 1954 from Middle Gully system of the Chinchilla Rifle Range by Stirton, Marcus and Woodward. It was during this phase that Jack Woods described the type section of the Chinchilla Sand (formally known as the 'Chinchilla Formation' in Woods 1960) and Alan Bartholomai began his long research association with Chinchilla. As focus on research output increased and more strategic locality designations were required, Alan Bartholomai divided the Geosciences records into two numbering systems, QMF, for fossil information, and QML, for locality information. He established the QML system in 1964 with the first entry, QML1, a site on the banks of the Condamine River at the Chinchilla Rifle Range called Sand Scree. He subsequently regularly used 4-Mile Military maps, topographic maps, and site names to record the position of field sites.

Phase 4: 1971 – 1980. The Bartholomai Years. The significance of fossil material from the Chinchilla Sand became more widely recognised and active collection continued during this phase. Many QM curators journeyed to the Chinchilla area to collect surface fossils from the eroding gullies, mostly from Chinchilla Rifle Range sites. Alan Bartholomai continued his research, joined by QM Curator Michael Archer and a series of trips took place involving the Kelvin Grove Teachers College, who assisted with fieldwork. Kelvin Grove Teachers College lecturer Bernard Cooke, QM Curators Mary Wade, Jenaette Covacovich and Roland Mackay, also collected from the Chinchilla Sand with some minor input from the public. Locality accuracy continued to improve with the use of field maps, locality names, and map referencing using topographic, geological, and military maps.

Phase 5: 1981 – 2000. Casual Collector and Citizen Science - Cec and Doris Wilkinson. Alan Bartholomai was largely focused on his role as Director, but actively encouraged research and field work during this time. Many QM staff and associates assisted with collection and donation of material. This phase was probably more strongly dominated by the involvement of two local Chinchilla residents, Cec and Doris Wilkinson, who collected continuously from the Chinchilla Rifle Range for a period of 31 years, between 1982 and 2013. As well as the typical surface collection they carried out an excavation, recording all fossils excavated in the Wilkinson Collection

Register, which they donated to the QM, along with their extensive fossil collection in a series of donations from 2010 to 2019. This is the only known detailed collecting undertaken at the Chinchilla Rifle Range. Cec and Doris named many of the gullies and developed a local map that has since been used to relocate past collection sites with a high degree of accuracy.

Phase 6: 2000 – 2020. New Technologies. The development of digital technology, and the increase in access to equipment to record spatial data such as GPS, has seen vast improvements in recording accuracy during this phase. Devices like smart phones and satellite navigation units dominate this phase and assisted with verification of survey data for the digital map of the Chinchilla Rifle Range, Middle Gully system (Fig. 2). The map incorporates site and locality names, some basic field geology and the position of the Chinchilla Sand Type Locality and is the benchmark for all future collecting.

Tables 1 and 2 and figure 2 provide a summary of the historic and current data of the key areas considered in this publication. All associated GPS locations and/or map references are lodged with the Queensland Museum Geosciences Program and documented in their Collection Management System (Vernon).

DISCUSSION

Pliocene vertebrate fossils from the Chinchilla Sand have attracted the attention of collectors for 150 years. Multiple collectors over six identified phases have donated fossils and provided location data to the Queensland Museum State and Reserve Collections. The early collectors were pioneers and many deserve recognition for their attempts at recording their work under what would have been difficult conditions, and several museum directors, including Charles de Vis, Heber Longman, Jack Woods and Alan Bartholomai, were key to promoting and encouraging research at Chinchilla. Our review has compared and clarified specific site names and locality number designations for all phases of collecting, resulting in a full list of existing and comparative Chinchilla Sand fossil sites and localities. Several sites in the Chinchilla region, including 'Fairymeadow', Charleys Creek, 'Seven Oaks' and 'Tralee' were not discussed in this study as stratigraphic correlation with the Chinchilla Sand remains to be determined. Through this investigation, QML designations were found to be inconsistently issued and used. For example, in numerous cases QMLs were issued for single collecting events and not used again. While useful in collating and comparing past data, it is not recommended they are used in the future. The digital map of the Chinchilla Rifle Range, Middle Gully system, incorporating updated historical site names and collection localities, provides the first detailed map of the locality.

With the compilation of historical site records and collections from Chinchilla completed, future research can focus on collecting more detailed stratigraphic information on the Chinchilla Sand. Determining the relative chronosequences of these prior sites and the systematic excavation of new collection areas should be a priority. Current work on this front has begun, with the identification of the Chinchilla Rifle Range conglomerate as a potential marker bed. Palaeomagnetic and geochemical dating efforts are already producing promising results that will be important not only at the site level, but at regional and national scales. This work will be incorporated and documented in the Queensland Museum Collection Management System. This research is critical to resolve the degree of time-averaging present in the deposit, and the relative ages of individual specimens or species. As consistent with a best practice approach, all future collections at this site should include detailed recordings of stratigraphic contexts as well as GPS coordinates. At an absolute minimum, this should include the position of fossils relative to the conglomerate bed, where present. This will ensure that the next phase of collecting at Chinchilla will provide a detailed resource for understanding Australian Pliocene ecosystems and their faunas.

ACKNOWLEDGEMENTS

We recognise the importance of preserving geoheritage sites of national significance such as the Chinchilla Rifle Range, and acknowledge the outstanding contributions of both professional and amateur collectors to the Geosciences QM State Collection over a period of 150 years. The authors would like to thank members of the Chinchilla branch of the Sporting Shooters Association of Australia for access to the Chinchilla Rifle Range and for continued guardianship and surveillance of the site, in particular, Frank Truscott, John Davies and current President, Peter Dougall. We also thank Kylie Harris (Department of Environment and Science) for her enthusiasm and commitment to the protection of the Chinchilla Rifle Range Nature Refuge and Bradley Saunders (Department of Aboriginal and Torres Strait Island Partnerships) for his assistance with confirmation of historic Indigenous occupation of the area and his interest in this review. We acknowledge Cec and Doris Wilkinson for their significant involvement over 30 years and the donation of their Chinchilla Rifle Range fossil collection, between 2010 and 2019, to the Queensland Museum. To Alan Bartholomai, Michael Archer, Jack Woods, Ralph Molnar, Susan Turner and Henk Godthelp we thank you for providing information from personal field diaries, verifying locality data and sharing personal stories of past collection trips. Cec and Doris Wilkinson and Alan Bartholomai passed away before this paper was completed. Thanks also to the 2013-2017 Class 10 students and staff from Samford Valley Steiner School, the 2015-2017 Class 10 students and staff from Noosa-Pengari Steiner School and the 2013, 2014 Class 10 students and staff from Abhaya Steiner School, Hyderabad, India for surveying data and the production of the digital map. Thanks to QM colleagues Cathy Davies, Shannon Robinson (QM Library) and Lisa Porter (QM Collection Services) for their assistance with access to library and collection records and Andrew Rozefelds, Scott Hocknull (Geosciences), Robert Raven and Alan Rix for comments on the draft of this manuscript and suggestions about figure production. Thank you also to Mel Wilkinson, for encouragement and valuable assistance with this manuscript.

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Male Combat in the Yellow-Faced Whipsnake (*Demansia psammophis*).

Memoirs of the Queensland Museum - Nature. 63: 26. 2021. Among the Australian elapid snakes, male combat is a regularly recorded behaviour, with larger and stronger combatants presumably securing mating rights over smaller rivals (Greer 1997; Shine 1994). Numerous taxa display this behaviour, including various members of the genera *Austrelaps* (Shine 1991; Jenner 2004), *Cryptophis* (Shine, 1984), *Demansia* (Greer, 1997; Covacevich, 1994), *Hemiaspis* (Shine 1987; Greer 1997), *Notechis* (Greer 1997; Fearn & Staubman, 2001), *Oxyuranus* Shine, 1991; Greer 1997; McRae & Covacevich 1997), *Parasuta* (Turner 1992; Greer 1997), *Pseudechis* (Shine, 1991; Greer 1997, Lloyd & Trembath 2010) and *Pseudonaja* (Shine 1991; Greer 1997; Clemann *et al*. 2010). Although there have been prior combat observations in *D. psammophis* (photos by John Weigel circa 2010, pers. comm. Rick Shine), here I present the first published instance of male combat behaviour in this species (see Fig. 1, video footage also available on request from author).

On the 29th of October 2020 at 9:30 am, two *Demansia psammophis* were observed entangled and wrestling at Oxley Creek Commons in Brisbane, QLD, Australia. The snakes were photographed (Fig. 1) and filmed on a DSLR camera. A single snake was initially spotted on the north side of a drainage culvert around 9.15 am, known colloquially as Snake Gulley (-27.541012 S, 152.994962 E, WGS84, Fig. 2), before fleeing into the creek area. Returning to the culvert some 15 minutes later, two snakes were found in the same location as the first individual. The combatants were approximately 30 cm and 35cm in Snout Vent Length (SVL) respectively, based on best visual estimate. While these individuals are small for mature *D. psammophis*, mature adults have been recorded at 318 mm in Greer (1997). Both were interlocked and occasionally rolling in rapid succession, each attempting to press the body and head of the other downward, often while both moving in a backward direction. The pair appeared to mainly fight in a low, horizontal posture, typical of small and lightly built species, and I did not observe the paired intertwining and raising of combatants' heads, followed by downward slamming, as has been noted in larger and more muscular elapids (Shine 1991, 1994). The pair continued wrestling over an area of perhaps six square meters, mostly on the grassy banks but occasionally entering the shallow edge-waters of the drainage. This behaviour continued until 9:37 am. Considering the early pass of the area and observation of just one individual around 9.15 am (give or take five minutes), this behaviour must have lasted for at least seven but no longer than 22 minutes, whereupon the seemingly smaller snake decoupled from the larger individual and fled northward along the north-eastern drainage bank with the larger snake in pursuit, until both were lost from sight. While neither snake was subsequently captured for explicit sex determination, the author has previously observed mating in this species, noting that it is much more docile than the observed combative wrestling.

Male combat in this species is expected, with previous work by Shine (1994) demonstrating the prevalence of male combat in sexually dimorphic snake species with larger males. This bias towards larger males is evident in *D. psammophis*, with a mean SVL of 52.5 cm for females and 57 cm for males (Shine, 1994). With regard to *D. psammophis*, Shine (1994) previously noted; "combat not reported for this species, but inferred because it occurs in congeners". Indeed, Covacevich *et al.* (1994) recorded male combat in the congeneric *Demansia vestigiata*, and photographic records of male combat in this species are available online

FIG. 1. *Demansia psammophis* in combat.

FIG. 2. Location.

(https://www.ecologyasia.com/verts/snakes-png/black-whipsnake.htm). In view of these observations, it seems reasonable to suggest that male combat may be ubiquitous in *Demansia* spp.

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The provenance of diagnostic specimens of the 'New Guinea Singing Dog'

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ABSTRACT

The New Guinea Singing Dog (NGSD) has been diagnosed as a distinct taxon on the basis of (1) two live animals, thought to be wild dogs, either free-living or captive, at the times when they were obtained by Europeans, (2) cranial material from 26 dogs, captive-bred descendants of the original pair, and (3) a single skull reportedly from a free-living wild dog. The NGSD is currently regarded as a behaviourally, morphologically and genetically distinct wild dog found at scattered high-altitude locations on mainland New Guinea, isolated from places where people live and, hence, largely isolated from village dogs associated with those people. We examined historical records to show that few, if any, of the founding members from the captive population of NGSDs, or dogs that served to diagnose *Canis hallstromi* Troughton, 1957, were, in fact, wild dogs or recent descendants of wild dogs. The continuing insistence that high altitude, wild-living NGSDs are a discrete population of dogs is incorrect. Rather, we recommend additional studies of village-living dogs across the span of altitudes and contend that these would yield much information about what was once a pan-New Guinean population of an unusual, and archaic, form of domestic dog.

❑ *New Guinea Singing Dog, Hallstrom's dog, New Ireland dog, dingo, village dogs, wild dogs.*

In 1957, the Australian Museum mammologist Ellis Troughton described two live dogs from 'Papua' (Fig. 1) as holotype and allotype of a new species that he named *Canis hallstromi* 'in honour of Sir Edward Hallstrom, President of the Taronga Park Trust'.

The dogs were held by Taronga Zoological Park (hereafter Taronga). According to Troughton they were a 'pair of the mountain "dingo"' that had been obtained in 1956 by Assistant District Officer J. P. Sinclair and Medical Assistant Albert Speer 'in the remote Lavani Valley [of the] Southern Highlands District of Papua' (1957: 93). Troughton considered that they were the same as 'dingo-like' dogs reported decades earlier from '7,000 ft. on Mount Scratchley', Owen Stanley Range. Skins and skulls of Mount Scratchley dogs, held by the Queensland Museum had been described by de Vis (1911), Longman (1928) and Wood-Jones (1929). Troughton agreed with Wood-Jones' opinion that the 'Papuan dog' was 'a very definite race … differing widely in its characters from the dogs of certain other Pacific islands' (1957: 93). In a later paper Troughton (1971: 93) reinforced his opinion that the dog he had described was a primitive, wild-living

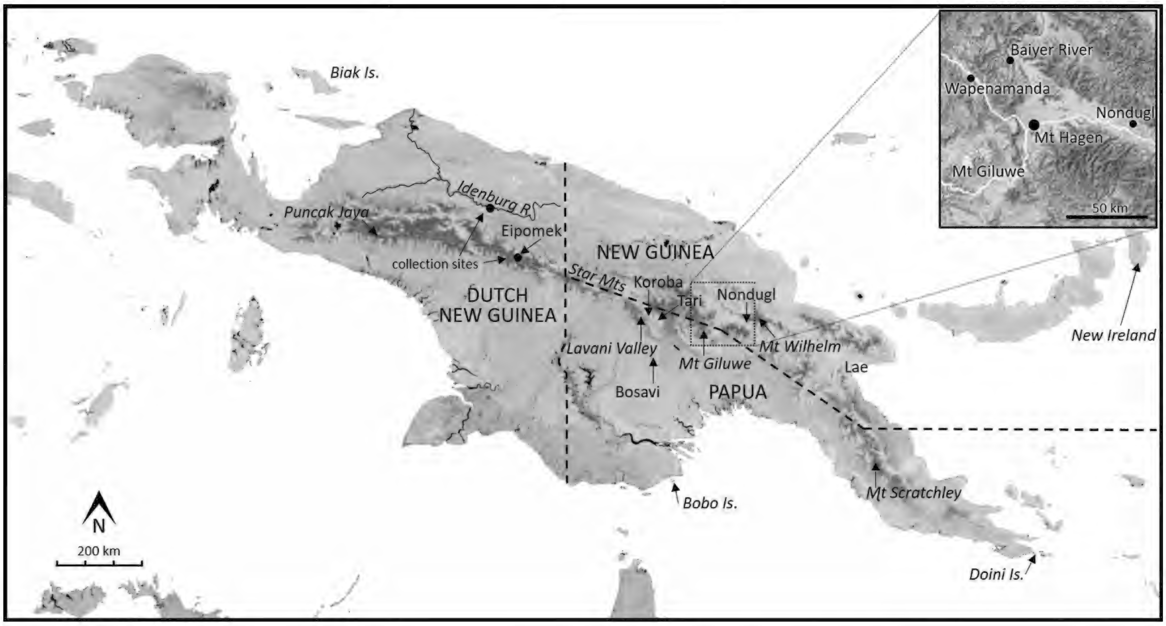

FIG 1: Mainland New Guinea showing colonial territories in the mid-20th Century and named localities.

species and insisted that use of the term 'feral' for this New Guinea dog was incorrect.

Troughton's accounts of New Guinea dogs have provided historical props for assertions that a distinctive form of wild dog, variously named New Guinea Singing Dog (NGSD), New Guinea Highland Wild Dog, New Guinea Dingo, and in earlier years New Guinea Yodeling Dog, is present at scattered high-altitude locations of mainland New Guinea, isolated from places where people live and, hence, largely isolated from the village dogs associated with those people (Anon 1958, Koler-Matznick *et al*. 2007, 2016: 161-165, McIntyre *et al*. 2019). On two counts, this opinion remains controversial. Firstly, disagreement concerning the taxonomic status of the NGSD with some authors accepting the name *Canis hallstromi* Troughton, 1957 (Crowther *et al*. 2014) and others treating it, together with the Australian dingo, as *Canis familiaris* Linnaeus, 1758 (Jackson *et al*. 2017). Secondly, disagreement concerning the provenance of the founding members of the captive population as wild-living or village-living, and their status as wild, feral or domestic. Koler-Matznick *et al*. (2007: 49) wrote that the 'current captive singing dog population is descended from eight specimens not directly caught in the wild' and then commented that 'this does not mean, however, that these specimens were village *C. familiaris*'. Recent genetic studies, however, using samples from the captive population, treat those dogs as descendants of wild-living forebears (Surbatki *et al*. 2020) and, in direct contradiction to Koler-Matznick *et al*. (2007: 49), Cairns (2021) asserts that most of the captive NGSD population was 'founded by 8 individuals captured from the wild in 1950'.

Misunderstandings and misinterpretations of the historical record continue to the present time due, in part, to earlier errors and flawed assumptions being later accepted as fact. In this paper we direct attention to errors of both fact and interpretation in accounts of the NGSD with particular emphasis upon details of the provenance of specimens that were taken to be diagnostic of *C. hallstromi* Troughton, 1957 (Troughton 1957; Koler-Matznick *et al*. 2003). We show that the presumed status as wild animals, or as descendants from wild animals, of the founding members of the captive

population of NGDS is incorrect in some cases and in doubt for others. We reinforce an earlier argument that, at the time of European colonisation of New Guinea, high-altitude wild-living dogs and most village-living dogs 'comprised a single though heterogeneous gene pool' (Dwyer & Minnegal 2016: 9). We suggest that studies of village-living dogs throughout remote areas of New Guinea offer an opportunity to learn about what was once a pan-New Guinean population of an unusual, and archaic, form of domestic dog.

The provenance of the Taronga Dogs

In 1954, Troughton visited the Mandated Territory of New Guinea as a collector working on behalf of the Australian Museum. He 'hoped to obtain specimens' of dogs from 'Mount Giluwee [*sic*], where our host-mentor, Mr. N. E. P. Blood, had observed the dogs around villages at about 8,000 ft. on the 14,346 ft. mountain' (1971: 96). Blood was manager of Sir Edward Hallstrom's Livestock and Fauna Trust Station at Nondugl, in the Western Highlands District. On Blood's advice that his safety could not be guaranteed, Troughton did not visit those villages and, thus, did not obtain dogs.

While it was clear that Troughton hoped to obtain dogs like those described from Mount Scratchley, it was not clear whether the dogs Blood had in mind were village-living or wild-living animals or, indeed, whether Blood himself knew. At that time, it was doubtful expatriate observers would have seen them as different. Anthropologist, Meggitt (1958: 299), who undertook long-term research in the region of highland New Guinea, wrote: 'The indigenous dog is a handsome animal of stocky build and looks rather like a small dingo. Like the dingo, it howls but does not bark'. That description would have applied equally to village-living and wild-living animals (see also, Clarke 1971: 87; Healey 1990: 93). With reference to the years 1955-57, Meggitt commented that 'few of these dogs are to be seen within several days' walk of European settlement. Many were destroyed and eaten by their owners when they acquired fowls'. Bulmer and Menzies (1972: 486) reported that Kalam people had killed their dogs for the same reason though, by late 1971, they again kept dogs most of which were now 'wholly or partly of European-introduced stock'.

More than a year after Troughton had failed to obtain a New Guinea dog, Albert Speer, then a Government Medical Assistant based at Duna (later Koroba), Southern Highlands District, wrote to Sir Edward Hallstrom saying:

> I have in my possession here one of the local native dogs it is a true type of the indigenous Papuan dog. It is a male pup and has been in my possession now for over one month, and is I would say only 2 months old. … I did hear that you were anxious to obtain one of these dogs, and as I go on leave from here in August of this year, and will have to make some arrangements for the dogs welfare, I thought you might like to have it. … If you do need it, (and I may be able to get a female also if you want them) I would be only too pleased to let you have it …. (Correspondence Speer to Hallstrom, 31 May 1956; held by authors.)

Sometime later, from Duna, Speer wrote to Ted at Tari:

> Had a reply back from Sir Edward Hallstrom and he wants these two Kanaka Dogs sent over to Nondugal [*sic*], would you please see that they get away OK?
>
> I have sent Hubert with them and he can look after them until a plane lifts them off. Would you please look after Hubert and cargo Boy for food etc? I've told Hubert to keep the big dog (DUNA) on the leash, however as yet he hasn't done any damage around here. The small pup killed a chicken here. … (Correspondence Speer to Ted, undated; held by authors.)

On 5 August 1956, Speer again wrote to Hallstrom acknowledging the latter's thanks for the gift of the two dogs:

> … you owe nothing in the way of thanks,

I on the contrary am grateful to you for accepting the dogs, and I only hope that they are of benefit to you. (Correspondence Speer to Hallstrom, 5 August 1956; held by authors.)

The two dogs that Speer gave to Hallstrom reached Sydney, by boat from Lae, in March 1957 (Anon 1957; Fig. 2). The female was already pregnant and apparently gave birth to four pups about three weeks after arrival (Anon n.d.) Available correspondence does not reveal either the provenance of these two dogs or their status as wild-living or village-living. However, Troughton (1957: 93) wrote that the two dogs held by Taronga had been obtained in 1956 by J. P. Sinclair and Albert Speer 'in the remote Lavani Valley, or so called "Shangri-La"' of the 'Southern Highlands District of Papua'. Some writers suggested that Sinclair and Speer were the first Europeans to visit the valley (Koler-Matznick *et al*. 2007: 49).

James Sinclair and Albert Speer were not the first 'white men' to visit Lavani Valley. In May 1954, John Zehnder, a geologist with the Australasian Petroleum Company, spent three days in the valley investigating rumours of surface oil leaks in the area (Clancy 1954). Zehnder's visit received considerable attention in the press and, for a time, the valley was referred to as 'Shangri La' (Anon 1954, Simpson 1954a, Zehnder with Jones 1954).

Sinclair and Speer first visited Lavani Valley for two days in June 1955, arriving on the 26th, departing on the 28th, as part of a 62-day government patrol to populated areas northwest from Tari, Southern Highlands District (Sinclair 1955). Their patrol was not sponsored by Sir Edward Hallstrom and was not intended, even in part, as a search for dogs, wild-living or otherwise as some contend (Koler-Matznick 2018: 10). On the 27th, their only full day in the valley, Speer attended to health concerns at local communities and Sinclair, accompanied by guides and up to 70 armed men, explored the local area. These circumstances were hardly conducive to encounters with wild-living dogs. The only reference to dogs in their reports is a brief comment by Sinclair, included in a section subtitled 'Agriculture and animal husbandry', where he remarked that 'Many very good specimens of CANINE PAPUENSIS were seen, some particularly fine animals being seen in LAVANI Valley' (Sinclair 1955: 62). Except on the two days when crossing the range at 2,500 m ASL into and out of the valley, the patrol travelled between communities in a relatively well populated area.

In November 1955 Sinclair and Speer revisited the valley and spent about a month

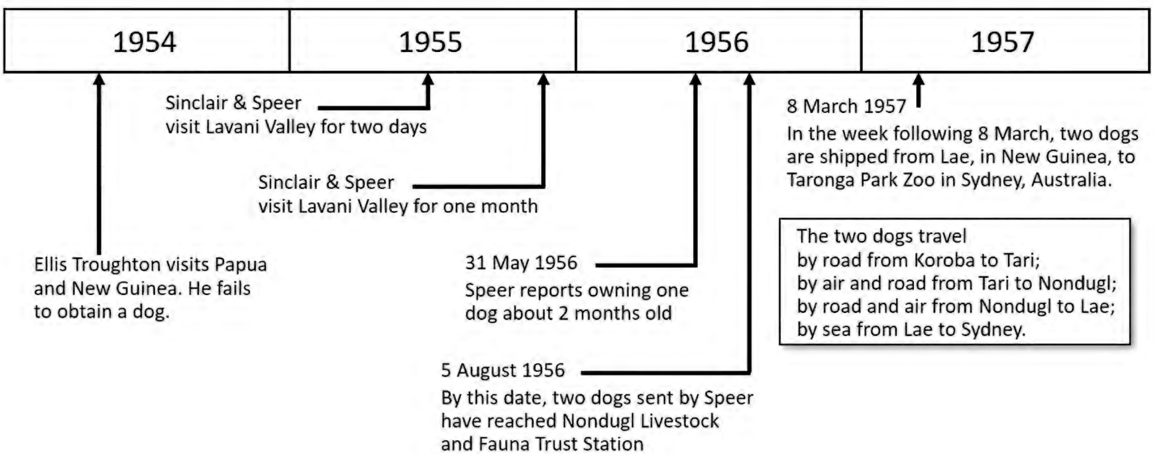

FIG. 2: Tracking the early history of the first two dogs to reach Taronga Park Zoo.

there. Speer again attended to health concerns. Sinclair spent time patrolling throughout the valley but, as on the earlier visit, was usually accompanied by large groups of men. There was no mention of dogs in his report from that month, nor was he impressed by earlier reports of a lost Shangri La (Sinclair 1956). He wrote of 'the bitter, inhospitable nature of [the] land' and R. R. Cole, Acting District Commissioner, commenting on Sinclair's report, wrote that 'the survey of Lavani Valley should now stop any further unrealistic publicity'.

Neither Sinclair nor Speer visited Lavani Valley again after 1955. The two dogs that Speer gave to Hallstrom were born more than three months after Sinclair and Speer had last visited the valley. Both were acquired by Speer during the time he was based at Duna (Koroba) as a government medical officer. His reference to them as 'Kanaka dogs' implies that, in his judgement, they were the kind of dogs that were kept by local indigenous people; his reference to the male as being 'one of the local native dogs' and 'a true type of the indigenous Papuan dog' reinforces this interpretation. He had, in addition, named his first dog 'Duna' after the place where he lived and the language spoken by local people rather than 'Huri' which was the language spoken by people of Lavani Valley.

It is noteworthy, that Sinclair's only mention of dogs in Lavani Valley was under the heading of 'animal husbandry'. He was, surely, writing of animals that were associated with people. Further, in this context, he named them 'CANINE PAPUENSIS', approximately two years before Troughton proposed the name *Canis hallstromi*. In earlier years, New Guinea village dogs were often referred to as 'Papuan dogs' in newspaper reports and the more formal rendition – *Canis papuensis* – may perhaps stem from knowledge of Miklouсho-Maclay's (1881) usage with reference to dogs found in villages on the northeast coast of mainland New Guinea. Miklouсho-Maclay had himself adapted the name from Ramsay's (1879) diagnosis of a coastal village dog from Papua as *Canis familiaris* var. *papuensis*.

Assertions that Sinclair and Speer obtained the dogs from Lavani Valley, and that their visit was sponsored by Hallstrom, are wrong. There is no available evidence that those dogs were either obtained from the wild or born to wild-living females. Rather, available evidence makes it more likely that they were the progeny of females that were owned by people and that lived in hamlets close to the government patrol post of Duna (Koroba). In those years, and in this region of New Guinea, people kept many dogs. In May 1939, Patrol Officer James Taylor, returning from the 15-month Hagen-Sepik patrol, paused for five days at Hoiyevia near the future location of Tari. When he departed on the 14th, his carriers 'took over fifty puppies they had bought' planning to re-sell them at Wabag (Gammage 1998: 199). Enroute to Wabag they camped in the mountains. The young dogs huddled together, almost frozen, until a 'fire was lit and they thawed out. They did not bark, but now and again one would begin howling and the rest would join in making a hideous chorus of wailing until their masters bullied them into silence' (Taylor 1939: 353). The assertions by Koler-Matznick *et al*. (2007: 49) that 'in general, canids did not fit within the Highlander's traditional way of home life' and 'most Highlanders usually did not, and still do not, keep *C. familiaris* as companion animals' overstate the facts.

Troughton's 1971 Observations

In 1971, Troughton published a paper titled 'The early history and relationships of the New Guinea Highland dog (*Canis hallstromi*)', in which he recorded the known distribution of *Canis hallstromi* as Mount Scratchley, Lavani Valley and the Indenburg River, in what was then Dutch New Guinea (Fig. 1).

While the presence of wild-living dogs on Mount Scratchley, and elsewhere in the Owen Stanley Range, is not in doubt, it is not known whether the Queensland Museum specimens derived from village-living or wild-living animals (Macgregor 1889; Anon 1929; Murray 1912: Chapter XI; Dwyer & Minnegal 2016: 2).

Longman (1928: 155) wrote that they were 'originally obtained from the natives'.

Of more significance, however, is Troughton's (1971: 96) acceptance of information in G.H.H. Tate's (1952: 613-14) report that, during the 1939 Archbold Expedition to Dutch New Guinea, 'Mr. W.B. Richardson … obtained five Papuan dogs at the Idenburg River'. Tate noted that in each of these dogs 'the carnassial length is more than 10 per cent of the condylo-basal length', and that Wood-Jones (1929) had taken this measure as showing that 'the Papuan dogs represented a primitive race' (Tate 1952: 614). Troughton concluded: 'Thus we have a very considerable extension of the highland range of a small dog of the same type [as that found at Mount Scratchley and Lavani Valley] in major cranial characters, from the opposite coast and beyond the border of the Territory of New Guinea' (1971: 96). Troughton failed to mention Tate's observations that the five Idenburg River dogs 'were brought into camp by natives' and 'presumably … were domestic, not wild, animals' (Tate 1952: 614). More tellingly, Troughton also failed to mention that one dog was received at an expedition camp located at 75 m altitude and the other four were received at an expedition camp located at 800 m altitude (Tate 1952: 614; see Fig. 1 in Rand 1940: 2). Thus, Troughton himself treated dogs received at low and middle altitudes – dogs that Tate assumed to be domestic – as being of the same kind as those he had described as a wild-living species confined to high altitudes.

Troughton commenced his 1971 paper by referring to reports from 1606 of a 'barkless' dog from coastal New Guinea. Diego de Prado wrote that at San Facundo Island (Blanchard or Doini Island) in the far east of New Guinea, 'we found small dumb dogs that neither bark nor howl', and that at Isla de los Perros (Bristow or Bobo Island) the dogs howled all night, 'which caused terror' though they proved to be good eating with their flesh 'better than that of venison' (Stevens 1930: 141, 158; see also A.R.H. 1941: 97-98).

Troughton considered that 'subsequent accounts indicate that this distinctive small dog was forced to the seclusion of a mountainous habitat by a combination of hostile circumstances'. This 'upland migration', he asserted, 'evidently occurred prior to hybridisation with any introduced breed of domesticated canine' (1971: 93). It seems that Troughton thought that this postulated 'upland migration' was very recent for he referenced reports from 1842 and 1886 in which lowland dogs were said to howl rather than bark. Troughton's flawed biogeographical reasoning has gone unremarked except by Gollan (1982: 208), who wrote that 'he uses the earliest historical reports of the coastal village dogs to validate the supposed ancient existence of the highland feral population'. Note, however, that Troughton considered the highland dogs to be 'wild' not 'feral'.

An updated description of the New Guinea Singing Dog

In 2003, Koler-Matznick *et al.* published a detailed, expanded description of the NGSD. They supported Troughton's identification of this dog as a unique, wild-living, taxon but acknowledged that 'further studies are needed to clarify the exact level of taxonomic differentiation of this rare and possibly highly endangered canid' (Koler-Matznick *et al.* 2003: 109). Measurements from 15 skulls provide the primary basis of Koler-Matznick *et al.*'s diagnosis. Figure 3 summarises available information concerning the provenance of those skulls (Koler-Matznick *et al.* 2003, Koler-Matznick 2018).

Five of the skulls, held by the Australian Museum, originated from Taronga, and comprised those of the holotype (M.8502), allotype (M.8917) and captive-born descendants of this pair. Measurements from two skulls held by the Australian National University were included; these came from seventh generation Taronga dogs (Gollan 1982). Four skulls were derived from descendants of dogs that had been exported from Taronga to the United States of America, which were themselves descendants of the pair of dogs described by Troughton.

One skull, obtained by James McIntyre in 1996 from a village in the Star Mountains,

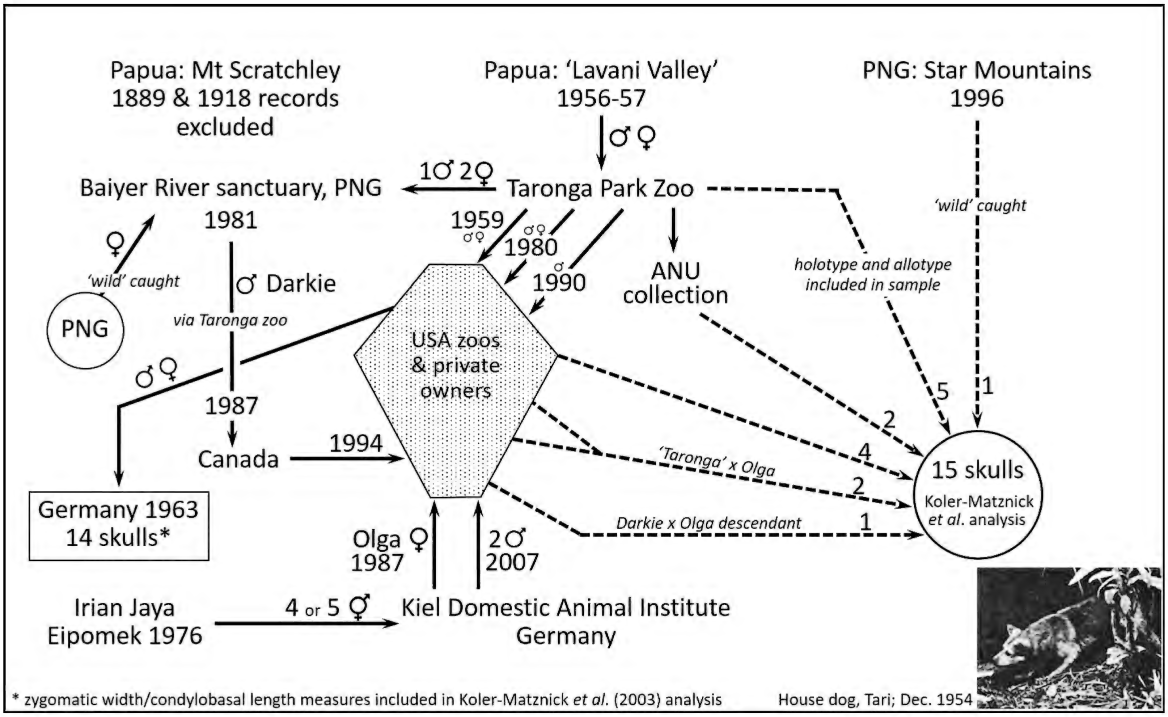

FIG. 3. The provenance of founding members of the captive New Guinea Singing Dog (NGSD) population and of specimens used to formally diagnose that dog. The photograph is from Simpson (1954b).

was reported by local people to be from a wild-living dog (McIntyre 1996). McIntyre considered that dogs living in the village were 'remarkably similar' in morphology, colouring and vocalisations to captive NGSDs (McIntyre n.d.).

In the 1970s a German interdisciplinary team initiated long-term research among Mek-speaking Eipo of the Eastern Highlands of what was then named Irian Jaya, Indonesia (Ploeg 2004). In 1976, four or five dogs from the region were relocated to the Kiel Domestic Animal Institute, Germany, for breeding and research. (Schultz & Gunter 1978, wrote that 'some' dogs were taken to Germany; Voth, 1988: 3, gave the number as four and Koler-Matznick *et al.* 2003: 109, referencing both sources, gave the number as five.) In 1987, Olga, a female descendant of the Eipo dogs, was sent to the United States. Two of the skulls measured by Koler-Matznick *et al.* (2003: 110) 'were Papuan × Irian Jaya'; from matings between male dogs of Taronga (Papuan) ancestry and Olga (Irian Jaya).

In 1981, a male dog named Darkie was born at Baiyer River Sanctuary to a male imported from Taronga and a female said to be wild-caught from the vicinity of Wapenamanda, about 25 km southwest of Baiyer River (Anon 1979, Koler-Matznick *et al.* 2000: 242). In 1994, Darkie reached the United States via Taronga and Canada. One skull included in the Koler-Matznick *et al.* (2003) analysis was born to a female descendant of Olga that had been mated to Darkie.

Koler-Matznick *et al.* accepted that, at the time they were obtained, the Eipo dogs were village-living. They wrote, however, that 'the Eipo tribe of the Irian Jaya Highlands kept and bred tamed NGSDs as social partners and playmates for children' (2003: 115) and, later, that the dogs taken to Germany 'had reportedly been bred by the locals' who were 'apparently one of the few traditional people who actually allowed their captive singing dogs to breed' (2007: 49). They cite Voth (1988) in support of

these assertions but have misread that source. Voth (1988: 4-7) reported information received by interview from expedition members W. Nelke and G. Koch. Nelke had spent more than two years living among the people. Voth wrote of the close relationship between Eipo people and young dogs, noting that 'adult dogs increasingly withdraw into the forest in search of food' and suggesting that 'in addition to these village dogs, fully wild dingoes presumably also live in New Guinea's primeval forests' (1988: 5). Nelke and Koch did not confirm the existence of wild-living dogs in the area. They reported, however, that local people spoke of 'solitary, black, "wild" dingoes who come into the valley occasionally from the north, and are then hunted and killed; persecution of black dogs is rooted in the people's spiritual beliefs' (Voth 1988: 6).

In addition, Voth (1988: 5) wrote that 'this Papuan tribe also practices a primitive kind of selection for external beauty; dogs with light color and well-developed white markings are preferred for breeding. When a bitch is in heat, the pair is confined in a garden hut; the tamer females often whelp there as well'. Voth is writing about a population of village dogs and not, as Koler-Matznick *et al*. (2003) contend, about wild dogs that are being bred by local people. Indeed, the colour of the dogs favoured by Eipo people is in complete contrast to the colour of dogs they assert to be wild.

In summary, the Eipomek dogs that were taken to Germany were village dogs with no known wild dog ancestors. Olga was a descendant of those village dogs. In 2018, Koler-Matznick wrote that 'today all Singers in the USA trace back to Olga on the female line' (2018: 11).

Koler-Matznick *et al*. (2003: 111, Table 1) used four measures to compare USA captive NGSDs with Thai dog, desert *Canis dingo*, *Canis aureus*, *Canis lupus pallipes/arabs*, 'Papuan dog' and Shiba Inu. Data for 'Papuan dogs' came from 13 skulls collected by Thomas Schultz-Westrum in the Mt Bosavi area (around 600 m ASL; Boessneck and Meyer-Lemppenau 1969); these skulls were from village-living dogs that had died in an epidemic. The four measures used by Koler-Matznick *et al*. were zygomatic width/condylobasal length, shoulder height, shoulder height/head-body length, and head length/shoulder height. A major difference between NGSDs and the Bosavi dogs was observed in the ratios of head length to shoulder height (NGSD 0.52-0.54; Bosavi dog 0.33-0.34). However, Boessneck & Meyer-Lemppenau (1969) had not reported head lengths of the Bosavi dogs. Koler-Matznick *et al*. (2003: 111) used total skull length as an approximation, acknowledged that skull length would probably be 'slightly smaller [than head length] owing to lack of the extension of the nose pad beyond the prosthion', but did not estimate the likely resultant bias. Using their own data for NGSDs the ratio of skull length to shoulder height would be about 0.41 to 0.45, notably less that the reported ratio of 0.52-0.54. Further, Boessneck & Meyer-Lemppenau (1969) had access to only skulls. Their measures of shoulder height were derived from a regression equation that estimated shoulder height in dogs from the length of the inner brain cavity of the skull (Wyrost & Kucharczyk 1967). Boessneck & Meyer-Lemppenau expressed doubt about the estimates obtained. Koler-Matznick *et al*. (2003), however, did not indicate either that measures of shoulder height for Bosavi dogs were estimates or that those estimates were problematic. The comparison of NGSDs and Bosavi (Papuan) dogs reported in Table 1 of Koler-Matznick *et al*. (2003) is not reliable.

In 1963, the Keil Domestic Animal Institute in Germany received a pair of NGSDs from the San Diego Zoo, USA. Schultz (1969) studied descendants of this pair and his measures of the ratio of zygomatic width to condylobasal length for 14 skulls were included in the Koler-Matzncik (2003) analysis. In his own contribution, Schultz (1969: 66) accepted Troughton's diagnosis of these dogs as *Canis hallstromi* but argued that 'the descendents [*sic*] of the original two dogs, which were bred in Kiel, did not prove to be members of a genetically uniform population as postulated in the beginning'. He argued also that the combination of several morphological features 'as well as zoogeographical

considerations appear to justify the statement that the Hallstrom-dogs are dogs returned to a wild state'. Schultz considered wild-living NGSDs to be feral. Troughton (1971) and Koler-Matznick (2007: 48) disagreed with this opinion.

In 1979 the Museum of Berlin held an exhibition about the Eipo research project (Ploeg 2004: 37). Schultz & Gunter (1978) wrote an information sheet introducing zoological matters. In this they named the Eipo dogs as *Canis lupus f. familiaris* where, following Bohlken (1961), '*f*' indicates that the 'form' *familiaris* is a domesticated wolf (*C. lupus*; see also Voth 1988: 1). In none of the publications accessed by us, have German workers treated the Eipo dogs as wild animals.

Finally, Koler-Matznick *et al*. (2003: 110) excluded the Mt Scratchley dogs from their diagnosis of the NGSD. They wrote: 'as they were apparently obtained from the indigenous people, their provenance is uncertain and they were not included'. However, in a later paper (Koler-Matznick *et al*. 2007: 48), the 1897 Mt Scratchley dog is accepted as 'the first specimen available for examination'. No explanation is offered for the change in opinion.

DISCUSSION

The captive population of NGSDs is derived from seven or eight founding members. None was captured as a wild-living dog.

Published accounts of the history and provenance of the first pair of these dogs to reach Australia are wrong in asserting that they were obtained by Sinclair and Speer when these men visited Lavani Valley on an expedition sponsored by Sir Edward Hallstrom. Available correspondence, and details about the age of the dogs when they were given to Hallstrom, support our judgements that the dogs were obtained from people who lived in the vicinity of the government station at Duna (Koroba) and that Speer, who organised the gift to Hallstrom, considered such dogs to be the 'true type of the indigenous Papuan dog' (see photograph of house dog included in Fig. 3). In 1956, it would have been impractical, for both financial and logistical reasons, to organise an expedition from Duna to Lavani Valley that had the express purpose of acquiring a wild dog and was not accompanied by an expatriate government officer. Further, given that wild-living and village-living dogs appeared to be phenotypically indistinguishable, the status of a dog obtained in these circumstances would be in doubt.

There is no ambiguity in accounts of the provenance and status of the four or five dogs collected from Eipo people in 1976. They were village-living dogs with no known genealogical links to wild-living forebears.

The last founding member of the captive NGSD population is the female, held at Baiyer River Sanctuary, that was mated to a male from Taronga and gave birth to the dog Darkie that was subsequently sent to USA. Though this female was said to have been wild-caught, no details of her capture and history are available and, hence, her status as a wild dog is not guaranteed. Further, in our judgement, as argued above, there is no evidence that Darkie's sire had wild-living forebears.

Troughton (1971) accepted that dogs from Mt Scratchley, the two dogs reported to be from Lavani Valley, and dogs from Indenburg River were representatives of the form he had named as *Canis hallstromi*. There is no unambiguous evidence that any of these animals was a wild dog. Troughton's own reporting contains errors and inconsistencies.

With one exception, the skulls used by Koler-Matznick *et al*. (2003) to diagnose *C. hallstromi* Troughton, 1957 were either those of founding members of the captive population (i.e., the holotype and allotype) or from dogs that were the descendants of founding members. Those with Eipo ancestry were not from wild dog stock and, in our judgement, nor were those with Taronga ancestry. The exception is the skull collected in the Star Mountains. Local people said this had come from a wild-living dog but there is no independent verification of that assertion.

There is no certainty that, at the time it was acquired by Europeans, any dog that became a

founding member of the captive population of NGSDs was either living freely as a wild dog, was a captive wild dog, or was the descendant of a captive wild dog. Similarly, there is no certainty with respect to possible status as a wild dog of any of the individuals that provided the cranial material used to diagnose *Canis hallstromi* Troughton, 1957. The skull from the Star Mountains is more likely than any of the others to be from a wild dog; skulls with Eipo ancestry are less likely than any of the others to have links to wild dogs.

Writing in 2018, Koler-Matznick (2018: 10) commented that 'today all Singers in the USA trace back to Olga on the female line'. Olga, a descendant of the Eipo dogs, was transferred from Germany to USA in 1994 where, in addition to mating with the Baiyer River dog Darkie (Fig. 3), she 'produced several litters sired by a San Diego Zoo/Taronga line male named Dinkum' (Koler-Matznick 2018: 10). Some pedigreed NGSDs are fourth and fifth generation descendants of Olga and Dinkum 'as they were the only pair reproducing for several years' (Koler-Matznick 2018: 10). There are important implications here for recent and on-going genetic studies. The maternal genome of any new samples taken from USA captive NGSDs will presumably be derived from that of Olga, a village dog from the Eipo region with no known links to wild dogs. The precise source of NGSD samples in recent genetic studies is also in doubt (Shannon *et al*. 2015, Oskarsson *et al* 2012, Surbakti *et al*. 2020). Oskarsson *et al*. (2012: 971) reported examining 'three NGSDs, representing the only three known female lineages'. If appropriate genetic material from females of the Taronga and Baiyer River lineages had not been held in storage for some years then there is not a good fit between the quoted assertions of Oskarsson *et al*. and Koler-Matznick *et al*. This matter calls for clarification in future studies.

In an earlier paper we argued that 'there is no convincing evidence that New Guinea wild-living dogs and some, or all, precolonisation New Guinea village dogs were distinct forms' (Dwyer & Minnegal 2016: 9). The present analysis reinforces that conclusion by arguing that few, if any, of the founding members of the captive population of NGSDs, or of the dogs that served to diagnose *Canis hallstromi* Troughton, 1957, were wild dogs or the recent descendants of wild dogs. Two important implications follow from this.

First, if the types of *C. hallstromi* were village dogs, as we argue, and the name *C. hallstromi* Troughton, 1957 refers to village dogs and wild dogs from all altitudes of New Guinea, then that name is a junior subjective synonym of *Canis familiaris novaehiberniae* Lesson, 1827. *C.f. novaehiberniae* was reported from New Ireland and Biak Island more than a century before Troughton wrote about New Guinea dogs (Dwyer *et al*. 2021).

Second, we accept the conclusion of Surbakti *et al*. (2020) that captive-bred NGSDs and the population of wild-living dogs found at high altitudes of Papua Province, Indonesia, in 2016 (McIntyre *et al*. 2019), are members of a single genetic population, allied to dingoes but distinct from breed dogs. Our argument that most if not all the captive NGSDs are derived from village-living dogs does not challenge this conclusion but, rather, extends its reach within New Guinea. Populations of village-living dogs that closely resemble NGSDs both phenotypically and behaviourally occur, to the present day, at both lower and higher altitudes throughout New Guinea, particularly in more remote regions where hunting by local people continues to be important (Dwyer & Minnegal 2016). These dogs often howl in synchrony ('chorus howling', Koler-Matznick *et al*. 2005: 42, 46), a vocalisation that Surbatki *et al*. 2020: 24369) assert is diagnostic of NGSDs and is unlike that of 'any other canid population'. It is likely that these village dogs are NGSDs or retain strong genetic links to NGSDs.

Following Jackson *et al*. (2017), we consider that NGSDs – wild-living, village-living and captive – are most appropriately named *Canis familiaris* L., 1758. Within this parataxon, however, they potentially qualify as an 'evolutionarily significant unit' in the sense of Moritz (1994; see also Koler-Matznick *et al*. 2003: 116, Surbatki *et al*. 2020: 24369) and, for

that reason, merit special attention with respect to conservation.

Increasingly, the original gene pool of these New Guinea dogs will have been, and will continue to be, diluted through interbreeding with introduced animals. To this time, the population of high altitude, wild dogs found at Puncak Jaya, Papua Province, Indonesia (McIntyre *et al*. 2019) has provided the only opportunity for studying these dogs in a free-living situation. Additional detailed observational and genetic studies of village-living dogs throughout remote areas of New Guinea offer an opportunity to learn much about what was once a pan-New Guinean population of an unusual, and archaic, form of domestic dog.

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A return to Hayman Island: revisiting Australia's only recorded cone snail fatality after 85 years

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ABSTRACT

The death of Charles Hugh Garbutt from a cone snail 'sting' inflicted at Hayman Island on the Great Barrier Reef marked both a family tragedy and an important moment in Australian medical and malacological history. However, aside from newspaper reports and the few witness statements given at the coronial inquiry, the events of that day in June 1935 and its immediate aftermath have never been critically evaluated. As memories of what happened have either faded or been partly distorted with the passage of time, the fatality today remains only a footnote in the history of studies on the Conidae and their complex, pharmaceutically-valuable venoms. The species involved, *Conus geographus* Linnaeus, 1758, is now recognised as the most dangerous to humans of the Conidae and responsible for most and possibly all recorded fatalities. After 85 years, the case is revisited using available evidence including newspaper reports, relevant scientific and popular literature, witness statements, archival documents and the actual specimen responsible for the fatality. While tragic and probably avoidable, the death, via its extensive coverage by the press, undoubtedly has helped to save lives by educating a public largely unaware of the dangers from something as seemingly harmless as a sea snail. It is also concluded that Charles Garbutt, when all factors are considered, was most unfortunate to have lost his life in the way that he did. For future cone envenomations it is recommended that photography (if possible) of the specimen involved would assist both in patient reassurance and medical treatment.

❑ *cone snails , Conus geographus, venomous gastropods, Mollusca, Great Barrier Reef*

Cone snails (Conidae) constitute an important world-wide family of carnivorous marine gastropods, found primarily in warm, shallow seas but also well represented in deep water (Walls 1979; Rockel *et al*. 1995; Kohn 1998). As their common name suggests, a large proportion of the family have a conical shell, and in the popular press and among collectors they are usually referred to as 'cone shells' or simply 'cones' (Marsh & Rippingale, 1964; Walls, 1979) (see Fig. 1). Conids are however best known for their dramatic method of hunting, which involves the use of complex, potent, peptide-based venoms (conotoxins) delivered by the proboscis in hollow, harpoon-like radular teeth (highly modified marginals) to paralyse prey prior to consumption (Boss, 1982; Röckel *et al*. 1995; Kohn, 1998; Oliveira *et al*. 2015; Gorson & Holford, 2016). The proboscis + radula tooth mechanism is often considered the biological equivalent of a hypodermic syringe, although in many cases the snail also uses the tooth to physically secure the prey item by gripping the knob-shaped base of the tooth with the proboscis tip (Marsh, 1977; Olivera *et al*. 2015). The prey may be 'worms'

(polychaete annelids, hemichordates or sipunculids), other gastropod molluscs, or fish, and although several cone species may show mixed food preferences most can be classed as predominantly or exclusively vermivorous, molluscivorous or piscivorous (Kohn 1956, 1959, 1963, 1966; Endean & Rudkin 1963, 1965; Miller 1989; Rockel *et al*. 1995; Kohn *et al*. 1960, 1999; Duda *et al*. 2001, 2009; Olivera *et al*. 2015). Of the 960 accepted species of Conidae (World Register of Marine Species as at 30th August 2020) at least 166 are recorded from Australia, mostly tropical Indo-West Pacific species, and of these 166, 133 occur in Queensland waters (Jon Singleton, 2009, pers comm). Other member families of the Conoidea such as the various 'turrid' groups (e.g. Borsoniidae, Raphitomidae, Clathurellidae, Mangelidae) or augers (Terebridae) can employ the same specialised system of prey immobilisation as the Conidae (Boss 1982; Taylor *et al*. 1993; Kohn 1998; Tucker & Tenorio 2009; Bouchet *et al*. 2011), but only the Conidae have managed to impact the health of humans through their ability to inflict serious injury or even death (Flecker 1936; Hermitte 1946; Kohn 1958, 1998, 2016, 2018; Halford *et al*. 2015). All conids are capable of stinging, but for humans, molluscivorous and piscivorous species have long been recognised as the most dangerous, being responsible for all 36 of the recorded fatalities (see Kohn 2016). Many species from both of these hunting categories occur in tropical and subtropical Australia, and are particularly well represented on the Great Barrier Reef (Rippingale & McMichael 1961; Stanisic 1987; Wilson 1994; Coleman 2003; Jarrett 2011) (Fig. 1).

On the 25th of June 1935 Australia recorded its first, and to date only, medically-confirmed fatality from a cone snail envenomation when a 27-year-old man was stung at Hayman Island in the Whitsunday Group off the central Queensland coast (Fig. 2). The unfortunate victim was Charles Hugh Garbutt (Fig. 3A) of Ayr, a member of one of the most prominent Townsville families. Although identification of the species involved was initially confused, eventually it was shown to be *Conus geographus* Linnaeus, 1758, now known to be the deadliest species of Conidae for humans (Endean & Rudkin 1965; Yoshiba 1984; Kohn 2016, 2018). The case made medical and malacological history as it was the first confirmed record of a cone snail fatality from Australian waters (Allan 1935a,b; Iredale 1935a-d; Flecker, 1936) and was very widely reported in the newspapers at the time (see Appendix 1(i)). In the years since, the case has been referred to in numerous popular works (e.g. Roughley 1936; Allan 1938; Cilento 1944; Allan 1950; Gillett & McNeill 1959; Rippingale & McMichael 1961; Endean, 1964; Marsh & Rippingale 1964; Cleland & Southcott 1965; Stanisic 1987; Underhill 1987; Whitehead 1998) and is frequently cited in research papers (e.g. Cleland 1942; Clench & Kondo 1946; Hermitte 1946; Kohn 1963; Haddad *et al*. 2006; Bingham *et al*. 2012; Dutertre *et al*. 2014; Halford *et al*. 2015; Kohn 2016). Nevertheless, several facets of the story have never been thoroughly explored and many of the 'facts' blurred after almost nine decades. The Garbutt Family history, *'The Garbutt Family Footprint'* (an unpublished manuscript held in James Cook University Library, Townsville) records Charles as having died at Hamilton Island after standing on a stone fish (Appendix 3). With the rapidly expanding interest in the pharmaceutical/medical applications and physiological properties of conotoxins (or their peptide components), focus on the biology and impact of cone snails on humans has never been greater (for reviews of the now vast literature on this topic see Terlau & Olivera 2004; Layer & McIntosh 2006; Bingham *et al*. 2010; Lewis *et al*. 2012; Gorson & Holford 2016; Olivera *et al*. 2014, 2017; Prashanth *et al*. 2014; Gao *et al*. 2017; Ai-Hua *et al*. 2019). As a result, there is a new appreciation of recorded history applying to envenomations (Kohn, 2016, 2018) and as a consequence the case of Charles Garbutt has once again become of scientific interest (Bingham *et al*. 2012; Dutertre *et al*. 2014; Halford *et al*. 2015).

This paper re-examines, interprets and then reconstructs the events of that day and its immediate aftermath using newspaper reports of the time (primarily sourced via Trove, an

FIG. 1. *Conus* shells, 15 of the 38 species known to occur in waters around the Whitsunday Islands. All specimens from Hayman Reef, Hayman Island (May 1966) with the exception of B (Elephant Rock, Gould Reef) and C, D (Lady Musgrave Island). A-E fish-eating species; F-I mollusc-eating species; J-P worm-eating species. **A,** *Conus geographus* (QMMO81326); **B,** *Conus striatus* (QMMO81626); **C,** *Conus tulipa* (QMMO81709); **D,** *Conus catus* (QMMO81178); **E,** *Conus magus* (QMMO 81421); **F, G,** *Conus textile* (QMMO81686); **H,** *Conus marmoreus* (QMMO81436); **I,** *Conus episcopus* (QMMO81238); **J,** *Conus miles* (QMMO 81441); **K,** *Conus flavidus* (QMMO81290); **L,** *Conus planorbis* (QMMO81532); **M,** *Conus emaciatus* (QMMO81249); **N,** *Conus mustelinus* (QMMO81476); **O,** *Conus capitaneus* (QMMO81172); **P,** *Conus litteratus* (QMMO81380). (Image: J.M. Healy, Queensland Museum).

FIG. 2. Map showing Hayman Island in relation to major cities of the Queensland Coast mentioned in the text. Inset: Map of Whitsunday region showing position of Hayman Island in relation to 'Cannon Valley' (present day town of Cannonvale) and Proserpine.

online research tool of the National Library of Australia), together with pertinent literature (books and scientific papers) and archival documents of the Queensland Museum and the Queensland State Archives. An attempt is made to identify all the factors that may have contributed to the fatality and by so doing, show how such a tragic outcome could perhaps have been avoided. In addition, an opportunity is taken to document and discuss the actual specimen responsible for the death of Charles Garbutt as there has been confusion in the recent literature about it (see photographs in Dutertre *et al*. 2014 and Halford *et al*. 2015). It is timely that the 1935 death should be revisited as, almost 80 years later, and once again in the

FIG. 3. **A,** The only known surviving photograph of the victim Charles Hugh Garbutt (of Ayr, northern Queensland) probably originating from a football team photograph (from *The Townsville Daily Bulletin*, 26th June, 1935, p. 6); **B,** Advertisement for cruises on Bruce Jamieson's '*Cheerio*', vessel used by the Garbutt party (from *The Mackay Daily Mercury*, 30th April, 1938, p. 13); **C,** Bruce Jamieson, captain of the '*Cheerio*', also renown for his musical abilities on voyages. Image OM91-98-0001-0088, V1-FL1579078; **D,** MV '*Cheerio*' out of the water circa 1933. Image OM91-98-0001-0088, V1-FL1579066; **E,** MV '*Cheerio*' anchored off Hayman Island circa 1933. Image OM91-98-0001-0090, V1-FL1579088; **F,** Monty Embury, with 32.5 kg yellow-spotted trevally caught off Hayman Island circa 1933. Image OM91-98 0001-0074, V1-FL1578904; **G,** A party of low-tide fossickers on the reef at Hayman Island circa 1933. Image OM91-98 0001-0066, V1-FL1578808. Images A,B from Trove, National Library of Australia; C-G from Embury Family Photographs, John Oxley Library, State Library of Queensland (individual image numbers cited above).

FIG. 4. A party of low tide fossickers on the Great Barrier Reef (probably Heron Island) echoes the Garbutt party's reef walk of 1935 (Image from Roughley, 1936).

Whitsunday Islands, a young man in his 20's was reportedly stung by a cone snail on the 9th June 2015 (Watson 2015)), and as recently as May 2018, a teenage girl was stung by what was suspected as being a cone snail at Heron Island (Sbeghen 2018).

Setting the Scene

Despite depressed, post-war economic conditions or perhaps even partly because of them, there was substantial growth in domestic tourism in Australia during the 1920's and 1930's and tropical destinations were eagerly sought out, at least by those who had the opportunity and the means to go. For the state of Queensland, there was no greater attraction to visitors than the Great Barrier Reef, and travel to the tropical north and the reef in particular was actively promoted by the Queensland Government Tourist Bureau. Several boat operators ran chartered tours of the reef and associated islands, these usually being a combination of sight-seeing or fishing but some with a slant towards organised scientific natural history or what today we would probably term 'eco-tourism' (e.g. the 'Embury Expeditions' - see Hughes (1937) and Appendix 1 (ii)). In the 1930's a number of cruise proprietors worked the Whitsunday and Cumberland Island groups off the Central Queensland coast, among them (Robert) Bruce Jamieson, who had become one of the best known figures of the industry (Fig. 3B, C). His vessel, the '*Cheerio*' (Fig. 3D, E) operated primarily out of Bowen and Mackay and was a 15 m diesel motor and sail-powered (auxiliary) launch christened in 1930 at Frederickton on the Macleay River, New South Wales. It was designed and built by Jamieson expressly for the purpose of Great Barrier Reef and islands tours (commencing in 1934), the potential for which he had realised after visits to the reef in the late 20's and early 30's when he had participated in some of the Embury Expeditions. With a top speed of between

7.5 and 9 knots (approximately 13-16.6 km/hour), berths for 15 people but capable of conveying up to 20, refrigeration, and with the ability to carry or tow glass bottom boats for coral viewing, the '*Cheerio*' was one of the better touring vessels for visitors wishing to experience the Great Barrier Reef and environs. Undoubtedly newspaper and magazine stories of the wonders of the reef played a crucial part in attracting tourists and fishing parties (see articles listed in Appendix 1 (ii)). Among the most important draw-cards of the tours was the magnificence of the flora and fauna, in particular the diverse and colourful marine life. While most came for the fishing or were content to just look at the attractive corals and clams, some sought to take home a souvenir of their trip, usually in the form of a piece of coral or shells gathered on a reef walk (Figs 3F, G, 4). As we shall discover, it was the decision to collect shells, specifically a certain species of 'cone shell', that was to prove so tragic for one man.

THE INCIDENT:
A DETAILED EARLY ACCOUNT

It seems appropriate to begin this re-examination of the Garbutt fatality (25th June 1935) with a contemporary account based on an eye-witness's fresh recollection of that day. Probably the most detailed newspaper report was published in Ayr in the 'The Delta Advocate' (exact date unknown but possibly 28th or 29th June), and republished in *The Bowen Independent* on the 3rd of July, the day the coroner's inquiry was due to commence. It is significant because it was based on an interview conducted on Thursday the 27th of June with James Breen, one of the holidaying party (and one who had helped attend to the ailing Garbutt), and over six weeks before he gave his witness statement at the Coroner's Court in Ayr on the 13th August. Whether or not Breen relied on the newspaper report for his statement we do not know, but if he did not, then his versions of events recorded on the 27th June and 13th August are reasonably consistent. This story does contain a few factual errors, apparently originating in the reporting rather than the eye witness: for example, that the "shell and barb were sent to Sydney" (they were actually sent to Brisbane). Nevertheless, it effectively brings to life the dynamics of the day and hence is here cited in its entirety and exactly 'as printed'.

> "The full story of the circumstances in which Mr. C. Garbutt lost his life was revealed to our representative, who interviewed Mr. J. Breen shortly after his return to Ayr on Thursday morning (says "Delta Advocate").
>
> The party, said Mr. Breen, had spent twelve days cruising the islands in the launch Cheerio, owned by Mr. Bruce Jamieson, of Bowen, and had gone right out to Bushy Island.
>
> After experiencing a most enjoyable cruise, they were making a leisurely return and on reaching Hayman Island, where there is a nice reef from which the water quickly ebbs, leaving myriads of shells of all sizes and descriptions, they decided to make a stop to gather specimens. Every member of the party left the launch to gather shells and all returned to the vessel for lunch, leaving their collections on deck. Charlie had finished his meal first and immediately went up on deck to examine his collection, picking up a cone shell about 3 ins. long and 1 ½ in. in circumference. In order to find its colour he turned it over in his left hand and began to scrape the shell, when he felt a sting in the centre of the palm. Mr. Breen joined him on deck almost five minutes later and, showing him the shell, Charlie said "This shell stung me" and went on to demonstrate what had happened. A second later he said "Do you know, my hand is so numb you could cut it with a knife and I would not feel it". The two men sat side by side on the deck while Charlie pointed out that the prong at the point of the shell from which the sting had issued, using a fish hook for the purpose. Presently he

began to feel all over his lips and mouth and to complain of numbness, informing his companions, who were now concerned "I can't see the hut on the island". He was at once taken below to the cabin and given a dose of brandy, but said that he could not see out of the windows. Offered another nip of brandy he shook his head, managed to mumble something including the word "choke" and never spoke again.

Alarmed at the rapid turn of events, the party made a 20 mile dash for Cannon Valley, which was the nearest point and about 15 miles from Proserpine. Fortunately, a lorry was drawn up on the beach to which the sufferer was transferred with Messrs. Breen and R. Gray in attendance. Meanwhile another member of the party lost no time in telephoning the Doctor at Proserpine, and was informed that he would come out immediately in the Ambulance. To save every precious moment, it was decided to hurry the patient along to Proserpine and the Ambulance was met eight miles along the road. Charlie was alive, but obviously in a critical condition, being almost completely paralysed. He was transferred to the Ambulance with the Doctor and Mr. Breen in attendance, and on reaching Proserpine it was found that he had passed away. It was stated that the poison from the barbed sting directly affected the nerves and flew to the brain, the victim being unable to speak within an hour of the happening, although he appeared not to suffer any pain, being paralysed.

An inquest was held at Proserpine on Wednesday morning, and the shell and barb have been sent to Sydney for examination. It is understood that there are about 500 species of cone shells, the one which injected its deadly poison in the hand of Charlie Garbutt having a kind of feeler about 1½ inches long and about the thickness of the lead in a pencil, from which a very fine sting, like a hair about three-quarters of an inch long was projected. Under the microscope the sting appeared to be barbed from end to end.

The Director of the Queensland Museum, Mr. Longman, says that there are four varieties of poisonous shells in the Conus family. The shells themselves were quite harmless and danger from them was only to be expected when the living organism was within. It inflicted the sting by means of a long flexible tongue on which there were thousands of small teeth to be seen on a microscopic examination"

General media coverage at the time

The Garbutt case was widely covered by newspapers across the country from the morning after the death (26th June) onwards until as late as October in 1935 after which references to it become sporadic or woven into more generalised stories of marine life or travelogs (see Appendix 1 (ii)). Many of the earliest articles were brief but some, including the example quoted above, were more substantial and sought also to educate readers about 'cone shells' and how the death appears to have been caused by a sting from something as seemingly innocuous as a sea snail.

By the 1930's the Queensland Museum had, for many years, been compiling scrapbooks of newspaper items pertinent to its collections and/or staff, and some accounts of the Garbutt case from Queensland newspapers appear in the 1923-1948 volume (pages 190-192; Fig. 5). Particularly noteworthy among the cuttings is an article published in the *The Townsville Daily Bulletin* on the Saturday following the death (29th June) featuring a photograph of the specimen believed to have been responsible (and incorrectly identified in its caption as *Conus textile*), shown complete with the retracted animal and a wax vespas (matches) tin included as a scale bar (Fig. 5A). The photograph was credited to a certain 'L. Borserino' of Proserpine, who, after much searching through digitised

newspapers proved to be Louis W. Borserini an honorary ambulance attendant then stationed at Proserpine District Hospital (see Appendix 1 (iii)). [Borserini would go on to have a long career in the Queensland Ambulance Brigade, eventually serving as superintendent at Mitchell, Roma and Tagoolawah in western Queensland]. This illustrated article drew attention to Queensland Museum Director (Albert) Heber Longman's comments on dangerous species of cone snails (*Conus geographus* [as '*Conus geographicus*'] and *C. textile*) which attempted to explain the role of the radular teeth and proboscis (together conflated for the reader as the 'tongue') and their structural relationship with the venom gland. It seems very unlikely that Longman had identified the species as *Conus textile* as he would not have seen the article until it was printed, and we know from his letters (held in Queensland Museum archives) that he did not have a chance to actually examine the specimen itself until the middle of July 1935 when the Queensland Government Analyst (J.B. Henderson) forwarded it to the Queensland Museum. The misidentification as *C. textile* may be attributable to Henry Tryon, the former Government Entomologist, who in an earlier press report (Courier-Mail, 27th June 1935 – see Fig. 5C) ventured the name (as '*Conus textilis*') as the most likely culprit. It remains puzzling as to why the species was not quickly identified as *C. geographus*, even by just a keen shell collector, given the clarity of the Borserini photograph in *The Townsville Daily Bulletin* (29th June) and the fact that *C. geographus* and *C. textile* differ substantially in both shape and colour pattern (see Fig. 1). In another illustrated article, published on the 26th June in *The Telegraph* (p. 6) (Fig 5B), a photograph of two cone shells from the Queensland Museum collection (*C. textile* and *C. geographus* – both shells still extant in the collection) was included, together with a drawing of a single *Conus* radular tooth mistakingly said to illustrate the entire "radula or flexible tongue, showing poison gland and duct of venomous shellfish". The press sometimes found it difficult to interpret information received from scientists, and given that even today we are still unravelling the complexities of *Conus* biology (including aspects of the hunting process and venom chemistry and effects) this was to be expected. However, some of this confusion must rest with Longman's attempt to over-simplify the facts about cone snails for the benefit of newspaper readers (e.g. that Queensland had four poisonous *Conus* species, when in fact many species occur there, all of which are 'poisonous'; that the 'tongue' could bore into shells (true for murex and sand snails, although not for Conidae)). On the 1st of July 1935, *The Townsville Daily Bulletin* (p. 7) carried a short article on the case, this time seeking out some comments from the doctor who was with Charles Garbutt when he died, Dr Thomas Clouston. Aside from providing some general information on cone snails (which we know from one of his letters that he obtained from a book) the article also contained a reasonably accurate description of the radular tooth and the wound area: "Seen under the microscope the spike which injected the poison was about half an inch long and as fine as a very fine hair. The puncture in the hand was like a fine pinprick". Certainly the novelty of how the death occurred was not lost on the press, as evidenced by such arresting story titles as: 'Deadly Shell. Barbed Tenant Sting Kills' (*The Sun*, Sydney, NSW, 26th June, p. 16), 'Death From Sting Of Shellfish. Beautiful Cone Hides Deadly Spike' (*Border Watch*, Mt Gambier, South Australia, 27th June, p.1) and even the misleading 'Death Sting From Shell. Man Succumbs After Great Agony' (*The Courier-Mail*, Brisbane Qld, 26th June, p.13 – see Fig. 5D) (Appendix 1(i)). In general however, and to the newspapers' credit, there was relatively little in the way of exploitative sensationalism about the fatality, and most of the stories, though often republishing or paraphrasing previous ones (possibly for syndication reasons), relayed the facts, at least as far as they could be ascertained and understood by the reporters. The newspapers also repeated a number of the eyewitness accounts from the Coronial Inquiry hence giving their readers the most comprehensive background to the story possible at the time. The fatality was also discussed in the Australian scientific press, with small articles being published by staff of the Australian Museum (Sydney) (Allan 1935a;

A

THE FATAL SHELL.

The shell of the fish, which caused the death of Mr. Charles Garbutt. The sting was protruded from the point marked X. The box is introduced as a comparison in size with the shell.

Interviewed in Brisbane, Mr. Longman, Director of the Queensland Museum, stated that most dangerous poison shells were Conus Geographicus and Conus Textile. The shells of each variety were themselves quite harmless and that danger from them was to be expected only when the living organism was within. It inflicted the sting by means of a long, flexible tongue on which there were thousands of small teeth to be seen on a microscopic examination. This tongue also was used for boring into the shells of other sea creatures with a peculiar, rasplike action. At the base of the tongue was a poison gland which secreted the toxin, and the latter was ejected through a tiny duct. Its action was to cause paralysis and prostration and, in extreme cases death.

A Brisbane medical man said, whether the sting would be fatal, would depend upon the condition of the victim and, the quantity of toxin injected. There were well-marked local symptoms, followed by muscular pains and then paralysis, after which in some cases there followed collapse and death, the latter generally taking place when the victim was in a state of coma.

"CONUS TEXTILE."
(Photo by L. Borserino, Proserpine).

B

The Telegraph
WEDNESDAY, JUNE 26, 1935.

Four Kinds of Poisonous Shellfish

Found Widely on Coast

Death of Man in North

QUEENSLAND possessed four varieties of poisonous shell of the Conus family, and it was likely that when the shellfish whose sting was reported to have caused the death of a man at Haymen Island had been identified it would be found to be one of them, said the Director of the Queensland Museum, Mr. Heber Longman, to-day.

The shells, of which there were four excellent specimens in the Museum, were widely distributed along the Queensland coast to Moreton Bay continued Mr. Longman. The most dangerous, from the viewpoint of its toxicity, was Conus geographus, while C. textile had the prettiest markings. The shells could be easily identified after an inspection of those in the Museum, and it would be an excellent idea for people likely to come into contact with them to examine those on exhibition.

Single tooth
Radula or flexible tongue, showing poison gland and duct, of venemous shellfish.

Mr. Longman explained that the shells of each variety were themselves qutie harmless and that danger from them was to be expected only when the living organism was within. It inflicted the sting by means of a long, flexible tongue on which there were thousands of small teeth to be seen on a microscopic examination. This tongue also was used for boring into the shells of other sea creatures with a peculiar, rasplike action. At the base of ~~the tongue~~ was a poison gland which secreted the toxin, and the latter was ejected through a tiny duct. Its action was to cause paralysis and prostration and, in extreme cases death.

EFFECTS OF POISON.

A BRISBANE medical man said that while he had not come into contact with a case in which death had followed the sting of one of the Conus family of shellfish there were ample records of this having happened. To a large extent whether such a sting would or would not be fatal would depend upon the condition at the time of the victim and the

Two specimens of poisonous shellfish (Conus geographus and C. textile) in the Queensland Museum.

C

Courier-Mail
27 6 35

POISONOUS SHELLS COMMON

Sting Rarely Results in Death

Poisonous cone-shaped shell fish, similar to that which administered a fatal sting to a young man at Haymen Island on Tuesday, are common along the Queensland coast, and have been found as far south as Moreton Island, according to the Director of the Queensland Museum (Mr. H. A. Longman).

The collection at the museum, he said yesterday, included four distinct species of "conus" shell fish found on the coast. Each was notoriously dangerous, and paralysis frequently followed a sting, but, so far as was known, death rarely occurred.

The shell housed an elongated "tongue" bearing serrated edges of hundreds of teeth, each equipped with a poison gland. The fact that the shells were handsomely marked made them of interest to the public, but, while the outer shell itself was harmless, very careful handling was necessary to avoid a sting from the "tongue." The living organism within the shell was carnivorous, and the "tongue" possessed the power of boring through the casing of other shells and feeding on the organisms within.

In the opinion of the former State Government Entomologist (Mr. H. Tryon) the fatal sting came from a shell fish known as the "textile cone" (conus textilis, linn.), which was common along the Queensland coast. The "tongue" was usually drawn into the shell when the latter was disturbed, but Mr. Tryon agreed that incautious handling might well result in a dangerous wound.

He knew of only one previous instance in which death had resulted from a sting. This was in 1915, when a member of the crew of the mission steamer John Williams died within 12 hours of being stung by a "textile cone."

D

Courier-Mail
26. 6. 35

DEATH STING FROM SHELL

MAN SUCCUMBS AFTER GREAT AGONY

PROSERPINE, Tuesday.

Charles Garbutt (28), of Ayr, was stung by a shellfish at Haymen Island, and died while being taken to hospital.

At 6 o'clock this evening a local doctor and the ambulance brigade received a call to Cannon Valley, where it was stated that a man had been stung by a fish, and was in a serious condition. The ambulance left immediately, and met a lorry bearing the injured man. The doctor found that the patient's condition was very serious. He was placed in the ambulance, and a dash was made to town. Just as the car reached the hospital the man died.

Garbutt was a son of Mr. and Mrs. J. Garbutt, well-known Townsville residents. He was on a pleasure cruise among the Whitsunday Islands with a number of friends, and they were on their way home when a stop was made at Haymen Island. The party went on to the reef, and gathered a number of shells. Among them was a cone-shaped shell, which was nicely marked.

EYESIGHT FAILED

After the party had gone back to the launch Garbutt was examining this shell when a spike came out and pierced his hand. He told his mates that he had been stung, but did not complain of much pain until some time later. He said that his eyesight was failing, and complained of a burning sensation around the mouth.

He grew steadily worse, and was unable to stand, and had to be assisted below.

The launch immediately made for Cannon Valley, which was reached about dark. Garbutt was then unconscious. A lorry was secured to bring the body to Proserpine.

Arrangements are being made to obtain the shell believed to be responsible for Garbutt's death, so that it may be despatched to the proper authorities for identification.

FIG. 5. Newspaper articles about the Garbutt fatality extracted by the Queensland Museum Library for its scrapbook. **A,** Report illustrated with photograph by Louis Borserini of the actual specimen of *Conus geographus* (misidentified as *Conus textile*) responsible for death (from *The Townsville Daily Bulletin*, 29th June, 1935). **B,** Report illustrated with radular tooth of a worm-eating *Conus* as well as shells of *C. textile* and *C. geographus* (from the Queensland Museum Collection) (from *The Telegraph,* Brisbane, 26th June, 1935). **C,** The former Queensland state government entomologist Henry Tryon weighs in with a wrong identification of the species involved (from *The Courier Mail*, Brisbane, 27th June, 1935). **D,** Contrary to this headline Garbutt did not suffer any agonizing pain. (From *The Courier Mail*, Brisbane 26th June, 1935). (All images: G. Thompson, Queensland Museum).

FIG. 6. **A,** Dr Thomas Bennett Clouston (at left) who attended to Charles Garbutt in the ambulance to Proserpine Hospital, here shown at a meeting of the Ex-Sevicemen's War Emergency Association in 1942. **B,** John Brownlie Henderson), the Queensland Government Analyst. He examined the *Conus geographus* specimen sent to him by Clouston and concurred on the cause of death (image supposedly circa 1930 but probably later). **C,** Dr Hugo Flecker (shown here in 1932), published on the case in the *Medical Journal of Australia* in 1936. **D,** (Albert) Heber Longman (circa 1940), Director of the Queensland Museum at the time of the fatality. He correctly identified the species of cone snail involved as *Conus geographus*. (Images: A, Argus Newspaper Collection of Photographs, State Library of Victoria, SLV accession number H99.201/1914; B. State Library of Queensland, negative number 23451; C, Queensland State Archives (Item ID 1212244 (from Flecker's application for registration with Medical Board of Queensland); D, Queensland Museum Image Library: slide QM 71-024).

Iredale 1935a-d) and in more detail in illustrated papers to the *Medical Journal of Australia* which covered aspects of the case, cone diversity and biology and the past occurrence of cone envenomations (Allan 1935b; Flecker 1936). T.C. Roughley, in his timely *'Wonders of the Great Barrier Reef'* (1936) was probably the first author to incorporate the fatality into a popular book, although, with due consideration to the family, omitting Charles Garbutt's name. Press coverage of the event faded quickly however, and even in travel cruise articles relating to the Whitsunday Islands (including those involving the *'Cheerio'*) it is usually not mentioned (see Hou, 1938). Perhaps, and for obvious reasons, it was seen as being detrimental to reef tourism, although it is also worth noting that in articles appearing in the late 1930's some authors of travelog stories about reef trips used the word 'paralyser' in connection with some marine snails, presumably the more dangerous species of Conidae (see Coombs 2010).

Expert Opinion: correspondence between Clouston, Henderson, Flecker and Longman

A small but important group of letters pertaining to the Garbutt fatality, and written in the days and months after it are held in the archives of the Queensland Museum Library. It appears to be, as far as the present writer can ascertain, the only surviving correspondence between the four key professionals involved in analysis of the biological evidence: Dr Thomas Bennett Clouston (1878-1962), the Proserpine District Hospital physician who was with Garbutt when he died and later performed the post-mortem; Dr. Hugo Flecker (1884-1957), both a physician and pioneer researcher based in Cairns who had long been interested in poisonous animals and plants of Queensland; John Brownlie Henderson (1869-1950), the long-serving Queensland Government Analyst (from the Government Chemical Laboratory in Brisbane) and lastly (Albert) Heber Longman (1880-1954), then Director of the Queensland Museum, and a zoologist of considerable and wide experience (Fig. 6) (for further background to careers of Flecker, Henderson & Longman see Gibbney 1983; Gill 1986; Pearn 1996; Turner 2005). We are fortunate that all of these individuals saw the significance of the case to Australian science and furnished each other with copies of their exchanged correspondence because, in many instances, only the copies have survived. The letters are very informative and provide a unique window into the aftermath of the fatality as seen from the scientist's perspective. As all are unpublished, the opportunity is here taken to reproduce the more significant examples and, after each of them, offer commentary on their contents. It is surprising that neither Clouston, Henderson, Flecker nor Longman was asked to provide a statement at the Coronial Inquiry and I can find no evidence to indicate that any of the correspondence quoted below was examined by the courts. The letters are reproduced verbatim.

Letters from Dr. T.B. Clouston (Proserpine District Hospital)

(A) Clouston to Henderson (26th June, 1935)

Clouston wrote to the Queensland Government Analyst J.B. Henderson on Wednesday the 26th of June 1935, the day after the incident, giving a reasonably detailed summary of what had happened, particularly the steps leading up to Garbutt's death. The typed copy, is marked 'Copy' (typed) and although bearing Clouston's name, is, as would be expected, not actually signed by him.

> "Copy
> Proserpine
> N. Queensland
> 26.6.35
> The Government Analyst,
>
> Dear Sir
>
> Sorry to worry a busy man but I thought you might be interested in this case. Yesterday a man – Charles Hugh Garbutt aet 27 a member of a fishing party at Hayman Island met his death in an interesting way. About noon at low water the party gathered shells on the coral reef, later about 2.30p.m. in their launch Garbutt was examining a cone shell fish

and it stung him in the palm. He took no notice. There was no pain. After a time his hand became numb and about 20 minutes after the sting he complained that his lips were feeling numb. 10 minutes after than he said his sight was failing but his mates only laughed at him. Sometime after this about 15 minutes his legs became useless & he could not stand up and his mates realised that he was very ill. They came over to the main land and I met the party at about 7 o'clock. The man Garbutt was then deeply unconscious, pupils dilated, no corneal reflex and pulse very faint. We placed him in an ambulance but he died just before be [we] got him to hospital at about 7.30 or five hours after the sting. The period of unconsciousness was about 3 ½ hours. At the request of the Coroner I did a post-mortem this morning and found nothing abnormal, no sign of gastric or intestinal irritation, lungs & heart clear, at sides of heart a bit engorged. So I gave as my opinion as to the cause of death – sting from a cone shell fish, acute toxaemia.

Under separate cover I am sending to you

(1) The actual shell fish which stung Garbutt. Extract from a book that I found. "The cone-shells are essentially tropical molluscs and seem to be most common in coral reefs, nearly 500 different species are known. The cone shells are remarkable for a poison gland connected with the radula". The shell fish is at present alive and from the narrow end projects a tongue-like organ about the size of a small lead pencil. From the tip of this the sting protrudes. (Name) <u>Gastropod-stenioglossa – Conidae)</u>.

(2). The sting of the cone-shell fish (between 2 slides)

(3) A portion of the stomach (pyloric end) and contents in case you wish to exclude any possibility of poisoning by swallowing to make opinion as to cause of death more accurate from a scientific point of view.

If the shell-fish should be sent to someone else would you kindly do so.

Yours truly,
(signed) T.B. Clouston"

Comments. From this letter, written on the same day that he had performed the post-mortem and submitted the relevant official certificate to Police, we learn details of the event as Clouston understood them. He does not indicate from whom he had obtained his information on the circumstances of the sting or the symptoms shown by Garbutt after being stung (other than those he could observe himself in the ambulance), but we can presume that he spoke to friends from the boat who had attended to Garbutt and Jamieson the skipper of the *'Cheerio'*. Being a very experienced medical doctor, Clouston astutely recognised the importance of the case and, not only promptly completed his work on the deceased as far as he could, also insisted on contacting the Queensland State Government Analyst (Henderson) to confirm his suggested cause of death. He also had the foresight to secure the specimen that had been responsible - remarkably still alive on the 26th June, so presumably kept in sea water overnight - and then send it and its 'sting' and tissue samples from the deceased to Henderson for chemical analysis. Clouston also clearly indicates that he would leave it up to Henderson to determine who else might want to examine the cone specimen. It is not certain from which book the quotation (in Item (2)) is taken from, but Clouston later re-quoted it to the press for an article in the *The Townsville Daily Bulletin* (1st July, 1935, p. 7). The 'tongue-like organ' is undoubtedly the flexible and highly extensible proboscis which delivered the fatal 'sting'.

(B) Clouston to Henderson (10th July, 1935)

"Copy
Proserpine
10.7.35
J. Henderson Esq.

Dear Sir,

Many thanks for your letter. I have been in touch with Dr. Fletcher [*sic*] of Cairns in the matter of the shell fish and he says it is definitely not C. Textilis the shell that caused the fatality at Mare Is. so I would be very much obliged if when you send the shell to the museum you would ask them to let me know its identification. Dr. Fletcher says from the photograph it most resembles C. striatus. I have asked the boat men in this locality to obtain other specimens of this shell but so far they have not done so. I am glad you were able to exclude alkaloids in the stomach because that makes my diagnosis much more certain.

Yours truly,
(signed) T.B. Clouston"

Comments. The 'Fletcher' in this letter is obviously Dr Hugo Flecker of Cairns who had been, from the outset, keen on establishing the identity of the species of *Conus* responsible for the Garbutt death. Although Flecker was correct in concluding that the species was not *C. textile*, his suggestion of *C. striatus* was also wrong, but understandable given that *C. striatus*, like *C. geographus*, has a cylindrical shell with dark, broad mottling and a wide (anterior) aperture (See Fig. 1). The general confusion about the species identity was perhaps to be expected considering that most Australian medical practitioners of the day would not have had ready access to literature for identification of *Conus* species. Clouston was clearly pleased to hear that Henderson's results were at least supportive of his own conclusions, ruling out poisoning via ingestion. His efforts to obtain more live specimens of the cone may have been more for Flecker's research rather than for Henderson to perform any chemical analysis of the venom (and who had already indicated how difficult such work would be in his reply to Clouston of the 6th July 1935 – see below).

Letters from John Brownlie Henderson (Queensland Government Analyst)

(A) Henderson to Clouston (6th July, 1935)

"Government Chemical Laboratory
Brisbane
6th July 1935'
Dr. T.B. Clouston
Proserpine, N.Q.

Dear Sir,

Your letter and sample of the 26th June were duly received and examined.

As the amount of material for chemical analysis was small the whole of it was used in an examination for alkaloids but no alkaloids were found.

Judging from the circumstances I think the evidence so overwhelming that your diagnosis was correct. Many thanks for the interesting exhibit of the shell fish and the sting.

I of course made no attempt to isolate any poison from the shell fish as that would probably involve several months' work and the use of a considerable number of shell fish ere sufficient of the poison could be obtained to determine its composition and properties.

If you have no objection I would like to send the shell fish along to the Queensland Museum where it could be added to their classified collection.

Yours faithfully,
(signed) J.B. Henderson
Government Analyst"

Comments. Clouston had wanted confirmation that his post-mortem conclusions were sound, and had also needed to rule out any possibility of accidental poisoning. Henderson's reply was reassuring. Henderson also realised that he would need more specimens of the cone snail in order to attempt any analysis of the

venom, and at least for the purpose of the case, also knew that such analysis was unnecessary given the strong evidence of witnesses as to what had transpired. His decision to send the specimen to the Queensland Museum rather than retaining it indicates that he had not been requested to forward it (as evidence) to the Police in Brisbane or to the Coroner's Court in Proserpine.

(B) Henderson to Longman (12th July, 1935)

"Brisbane, 12th July 1935
The Director
Queensland Museum
Brisbane.

Dear Mr. Longman,

Enclosed herewith please find copies of correspondence with Dr. T.B. Clouston in reference to the death of Mr C.H. Garbutt, near Proserpine, from the sting of a shell fish. I also enclose the actual shell fish which caused death, and the sting, as received from Dr. Clouston.

As you will see he desires you to identify the shell for him, and seemingly, to keep the shell. Please let him know directly and thank him for the shell.

Yours faithfully
[signed] J. B. Henderson
Government Analyst"

Comments. Henderson, as per Clouston's wishes, makes sure that the specimen and the microscope slide containing the 'sting' (radular tooth) of the specimen associated with the death is deposited with the Queensland Museum. While both the specimen and the slide were definitely received by the museum (and each registered) only the specimen appears to have survived today (QMMO 1689).

Letters from Dr Hugo Flecker (Doctor, Cairns)

Hugo Flecker, a well-respected medical doctor and pioneer worker on the effects on humans of dangerous Australian animals and plants, had shown immediate interest in the death of Charles Garbutt and quickly wrote both to Clouston and Heber Longman wanting to know more about the case. The following hand-written letter to Longman sheds significant light on the state of medical knowledge in Australia at the time in relation to the dangers of venomous Australian marine animals, and in particular, cone snails.

(A) Flecker to Longman (29th June, 1935)

"70 Abbott Street
Cairns, NQ
29th June

Dear Mr Longman,

Dr Clouston writes that he has forwarded to you the species of Conus responsible for the fatality at Hayman Island. He has meanwhile forwarded to me, filled in in great detail, the form prepared by the Registry of Injuries Caused by Plants and Animals in Tropical Queensland.

At the recent Medical Conference in Cairns in March last, I exhibited a specimen of Conus textilis & quoted the report of a fatal case at Mare Is. in the Loyalty Group, as recorded 6th Report of Microbiological Lab. (N.S.W. Govt. Bur. of Microbiology for 1915 (p.164). I believe the Hayman Island case the first one actually reported from Australia in the literature.

I propose to initiate experiments firstly to determine the mechanism of the sting as (a) the source quoted attributes it to barbs in the mantle while (b) Hutchinson's Animals of All Countries states the poison gland is associated with the radula (p. 70-76).

I would be glad to learn of the identity of the Conus & meanwhile, I hope to get another specimen (or later live specimens) from Dr. Clouston.

Kindly greetings & best of wishes

Yours sincerely
H. Flecker

I am acting as Registrar for this Registry which is conducted by the B.M.A."

Comments. This letter is important for several reasons. We learn that Flecker's interest in cone snails and their known threat to humans existed well before Garbutt's death, and that he had correctly surmised that the case was the first recorded fatality from a cone snail in Australian waters. The 1915 case he refers to from the literature (Mare Island, Loyalty Group) was said to be from *Conus textile* (misspelt 'textilis' by Flecker possibly deliberately – see Extract from 4th August letter below) and he was keen to confirm whether this was also true for the Garbutt case. As registrar for the newly established 'Registry of Injuries Caused by Plants and Animals in Tropical Queensland' he had earlier (in late March or in April 1935) made available to doctors, including Clouston, a questionaire in which to record details of any cases known to them. Clouston was evidently very quick to respond with full details of Garbutt's death (his completed form is presumed now lost). However, it is uncertain as to why Flecker should say that Clouston had informed him that the specimen responsible for the death had been forwarded to Longman at the Queensland Museum when in fact Clouston clearly states in his letter of the 26th June to Henderson that he (Henderson) was to be the recipient of the specimen and letting him determine who else it should be sent to. Unfortunately, Clouston's letters to Flecker which may have clarified this point could not be found. Clouston's detailed account of the case, which according to Flecker's letter was contained in the completed questionaire for the 'Registry of Injuries Caused by Plants and Animals in Tropical Queensland', was subsequently used by Flecker in his paper on cone snail injuries for the *Australian Medical Journal* (Flecker, 1936). Surprisingly Flecker (1936, p. 466) cites Clouston as giving the date of the Garbutt death as "June 27, 1935" which was two days after the event and actually the day of the funeral in Townsville. Cleland (1942) has previously noted this discrepancy of dates, getting confirmation from the Bowen Registrar of the correct date (i.e. 25th June).

Typed extract from letter (4th August, 1935) to Longman:

"…..Many thanks for details of C. (or Nubecula) geographus. I have no specimen of this species available in Cairns and those promised from Haymen [sic] Island have not yet arrived. I have written for a reprint of Japanese article which you so kindly quoted. Meanwhile I will write up the very full notes which I have received from Dr. Clouston of the clinical symptoms which will probably appear in the Medical Journal of Australia.

With *Conus textile*, *C. geographus* and *C. nussatella*, there does not appear much respect for grammatical forms."

Comments. Obtaining literature on the subject of cone snail envenomations was obviously not an easy task in 1935. The "very full notes which I have received from Dr. Clouston of the clinical symptoms" is that contained in the questionnaire completed by Clouston for Flecker's 'Registry of Injuries Caused by Plants and Animals in Tropical Queensland'. The whereabouts of Clouston's completed form are unknown. Flecker apparently preferred to refer to *Conus textile* as '*Conus textilis*' in his communications apparently on the basis of grammatical aspects!

Letters from Heber Longman (Queensland Museum)

(A) Longman to Clouston (20th July, 1935)

"[To] Dr. T.B. Clouston
Proserpine, N.Q.
20th July, 35.

Dear Sir,

Through Mr J.B. Henderson, the Queensland Government Analyst, I have received the Cone shell from Hayman Island associated with the death of Mr.

C.H. Garbutt. This proves to be Conus geographus Linnaeus, which is apparently a less common species than C. textile. As some modern authorities prefer to divide the species of Conus (in the wide sense) into a number of genera and sub-genera, it should be mentioned that this shell is also listed as Nubecula geographus.

In view of the tragic circumstances, I appreciate your action in making this shell available for our collections as a definite record.

I have forwarded information and references to Dr. Flecker of Cairns, with whom you have correspondence, and doubtless you will hear from him again.

The fragments sent on the slide do not resemble the typical margin teeth figured for some species of poisonous cones, but we have no special knowledge of these.

Your efforts to obtain further specimens for research are appreciated.

Yours faithfully,
DIRECTOR"

Comments. In this letter Longman, as requested by Henderson (12th July letter), formally thanks Clouston for his diligence in securing the specimen of *Conus geographus* responsible for Garbutt's death and for ensuring that it was deposited in the Queensland Museum collection as a confirmed record both of the species and the event. However, the most significant part of the letter is Longman's statement about the microscope slide Clouston had prepared, supposedly of a radula tooth (or the 'sting' as it was often referred to). Clearly Longman was not convinced that the slide contained such a tooth but had to admit that the museum had "no special knowledge" on the subject. But this does raise the issue as to what was on the slide – was it radular tooth from the cone snail or something else? Given the fact that the slide cannot be located in the Queensland Museum collection today it is impossible to be sure. However Clouston's description of the 'sting' as being "about half an inch long and as fine as a very fine hair " (quoted in the Townsville Daily Bulletin, 1st July, 1935) is fully consistent with the shape and size of *Conus geographus* radular teeth (see Endean & Rudkin 1965; Thompson & Bebbington 1973; Dutertre *et al*. 2016).

Longman sent essentially the same letter as this one to Flecker on the same day (20th July), but added a note, in connection with *Conus geographus*, that "a Japanese, P. Sugitana in 1930 cites a case of poisoning by this species, but the publication, Venus (Tokio II, 3, 1930, p.151) is not available here". [The 'P. Sugitana' reference is that by F. Sugitani (Sugitani, 1930)]. He also sent him a paper (not specified) from the Records of the Australian Museum which Flecker had sought.

(B) Longman to Henderson (25th July, 1935)

"[To] Mr. J.B. Henderson, F.I.C.
Government Analyst, Brisbane, Q.
25th July, 35.

Dear Mr. Henderson,

The attached copies of letters to Dr. T.B. Clouston, Proserpine, and Dr. Flecker, Cairns, relating to the Conus shell from Hayman Island may be of interest to you.

With appreciation of your action in forwarding this shell to the Queensland Museum,

I am,
Yours sincerely,
DIRECTOR"

Comments. Like Clouston, Henderson and Flecker, Longman was pleased to send and receive copies of important correspondence, recognising their scientific and historical value. Longman was always courteous in acknowledging receipt of donated material to the Queensland Museum collections, and in this case, also ensured that the Queensland Government Analyst's Office knew that material had been safely received

and would be available for any subsequent consultation.

The Coronial Inquest

As no death certificate was issued on the day of the fatality (25th June) a Coronial Inquest was convened, initially, at the Proserpine Coroner's Court on the 3rd to 5th of July 1935 with Charles A. K. Morrison presiding, assisted by Constable David C. McQuaker. Some five weeks later (13th August) the inquest continued at the Ayr Coroner's Court, with A.M. Taylor presiding, assisted by a 'Sergeant Galligan', and concluded by Morrison at Proserpine court on the 16th of August. The first three witnesses gave their statements at Proserpine: Constable McQuaker (who was present at the morgue at Proserpine District Hospital on the morning of the post-mortem (26th June)), Robert Bruce Jamieson (owner and skipper of the *'Cheerio'*) and Robert Fred Bartlett Superintendent of the Proserpine centre of the Queensland Ambulance Transport Brigade (who had driven the ambulance and Dr Clouston to take Garbutt to Proserpine Hospital). The final two witnesses called gave their statements at Ayr: importantly both were members of the touring party (Joseph Malachy Breen of Ayr, a general carrier, and Robert John Gray of Ayr, a cane farmer). Considering the extremely unusual nature of the fatality, it is somewhat surprising that only five witnesses were called to give statements. For example, T.B. Clouston, the doctor who took charge of the unconscious patient in the ambulance to Proserpine Hospital and later carried out the post-mortem, was not asked. Possibly he was not available at the time. Certainly the court already had possession of the post-mortem certificate issued by him on the 26th June which clearly indicated his conclusions as to the likely causes of death (listed in order as "(1) sting from a cone shell fish; (2) acute toxaemia; (3) cardiac failure"). Presumably the court may also have inspected any other notes prepared by Clouston on the case, but if so, there remains nothing in the Coronial Inquest papers (Queensland State Archives Coronial Inquest 521/35) to confirm this. As Clouston was an experienced and highly respected doctor, and as he had performed the required post-mortem and provided the Queensland Government Analyst with relevant materials for expert opinion (i.e. the *Conus* specimen causing the death, a microscope slide with the 'sting', and tissue samples from the deceased), the court presumably felt this adequately covered medical aspects of the case. We know from the letter that Henderson (Queensland Government Analyst) wrote to Clouston on the 6th July 1935 that he agreed with him as to the likely causes of death, but again there is nothing in the Coroner's Inquiry file (521/35) to indicate that Henderson was ever asked for evidence or provided any correspondence from Clouston regarding the death.

Each of the five witnesses called to give statements obviously did so on the basis of what they knew and the extent to which they were involved: hence Constable McQuaker could comment only on the fact that he received from Clouston the post-mortem certificate and re-state its conclusions; and Superintendent Fred Bartlett who drove the ambulance could only relate the journey from Proserpine District Hospital (with Clouston}, to meet the lorry from Cannon Valley carrying Garbutt, as well as the journey back to the hospital. It was the three witnesses from the *'Cheerio'* (Jamieson, Breen and Gray) that were really the keys to establishing what had happened. Although there are minor differences in their recollections of the events in the immediate period following the stinging, the statements are generally in good agreement (Appendix 2). These three witnesses all agreed that the *'Cheerio'* had been anchored at Hayman (Island) Reef, either before or just after midday and that all passengers went on a reef walk, partly to gather shells. All members of the party returned to the boat by 1.30 pm and left their shell finds on deck, then went to lunch below deck. Garbutt had reportedly told Breen that he had collected a 'cone shell' and Jamieson remembers Garbutt attempting to clean the surface of the shell with a fish scaler before he broke for lunch. It was following lunch, sometime between 2-2.30 pm that Garbutt was stung by his cone specimen, after which he then tried to show Jamieson, Breen and

Gray (and possibly others) how it happened by trying to induce the snail to try again. Soon after the stinging Garbutt complained of numbing on and around the hand then the mouth, followed by rapid impairment of eyesight and subsequent loss of limb control. By 3.00 pm Breen and Gray had Garbutt retire below deck and Breen offered him some brandy to help his anxiety, but by about 3.30 pm his condition steadily declined and skipper Jamieson weighed anchor and headed immediately for Cannon Valley to seek medical help. During the two and-a-half-hour journey to Cannon Vale, Garbutt had lost consciousness, and as soon as the *'Cheerio'* arrived at Cannon Valley the doctor (T.B. Clouston) at Proserpine District Hospital was called. A lorry conveyed Garbutt along the Cannon Valley to Proserpine road to meet the ambulance and doctor, after which he was conveyed to the hospital but died just as the journey was completed.

The 'Certificate of Particulars – Inquest of Death' issued by the Coroner Charles Morrison found no suspects and no suspicious circumstances and stated the 'Supposed cause of death ' to be a "sting from a cone shell fish" in keeping with Dr Clouston's post-mortem certificate (although Clouston had added 'acute toxaemia' and 'cardiac failure' as additional factors). The documents associated with the inquest are today housed in the Queensland State Archives (Brisbane) (ID 349592; Inquest Number 521-1935).

Post-Coronial Evidence

Immediately following the Coronial Inquiry little new evidence relating to the death was published. Hugo Flecker, in his paper to the *Medical Journal of Australia* (Flecker 1936) did present a précis of information said to have been forwarded to him by Clouston soon after the fatality on a questionnaire form provided by Flecker. Although the basics of this information are correct, it is uncertain as to why Clouston is quoted in the paper as having received his facts about the stinging from "CHG's mother who was with him at the time". This is the first time Garbutt's mother (Margaret Garbutt of Townsville) is mentioned in any account of the story and it is certain that she was not a member of the *'Cheerio'* touring party and it is highly unlikely that she was at Cannon Valley (the present day town of Cannonvale) when the boat pulled in there given that the cruise was due to finish much further south at Mackay. Flecker also states that Clouston gave the date of the death as "June 27, 1935" – two days after the actual event. Again it seems unimaginable that the doctor who was with Garbutt when he died and who had performed the post-mortem should then provide the wrong date of death to Flecker in the first few days after it occurred (Cleland (1942) has already drawn attention to this inaccuracy in Flecker's paper). Unfortunately, the original questionnaire completed by Clouston or any other case notes he may have provided to Flecker are not locatable and have probably not survived.

Seven years after the fatality the notable South Australian pathologist and naturalist John B. Cleland published further details on the incident in a larger report on the diverse injuries to humans from animals in Australia (Cleland, 1942). This was based on information provided by the captain of the *'Cheerio'* R. Bruce Jamieson to Joyce Allan (then Assistant Conchologist to Tom Iredale at the Australian Museum), and passed on by her to Cleland. It is worth quoting the relevant part of Cleland's paper (p. 318) in its entirety as it reveals important new information on the circumstances associated with the immediate aftermath of the 'sting' and on Garbutt's health before the event:

"Miss Joyce Allan kindly supplied me with the following information, which was obtained from Mr. R. Bruce Jamieson, master of a motor launch that was on the scene at the time. Miss Allan has further stated that prostigmin was suggested as a likely antidote:

'The victim of the Cone shell poisoning was scratching the epidermis off a shell, since identified as Conus geographus (Dr. Cleland will recall this was the species which poisoned a European woman in Fiji), when the animal apparently shot out its proboscis and discharged a poison dart into the flesh of his hand. Little pain was experienced, however, but about an hour after, when he had returned to the boat from the reef, the victim complained

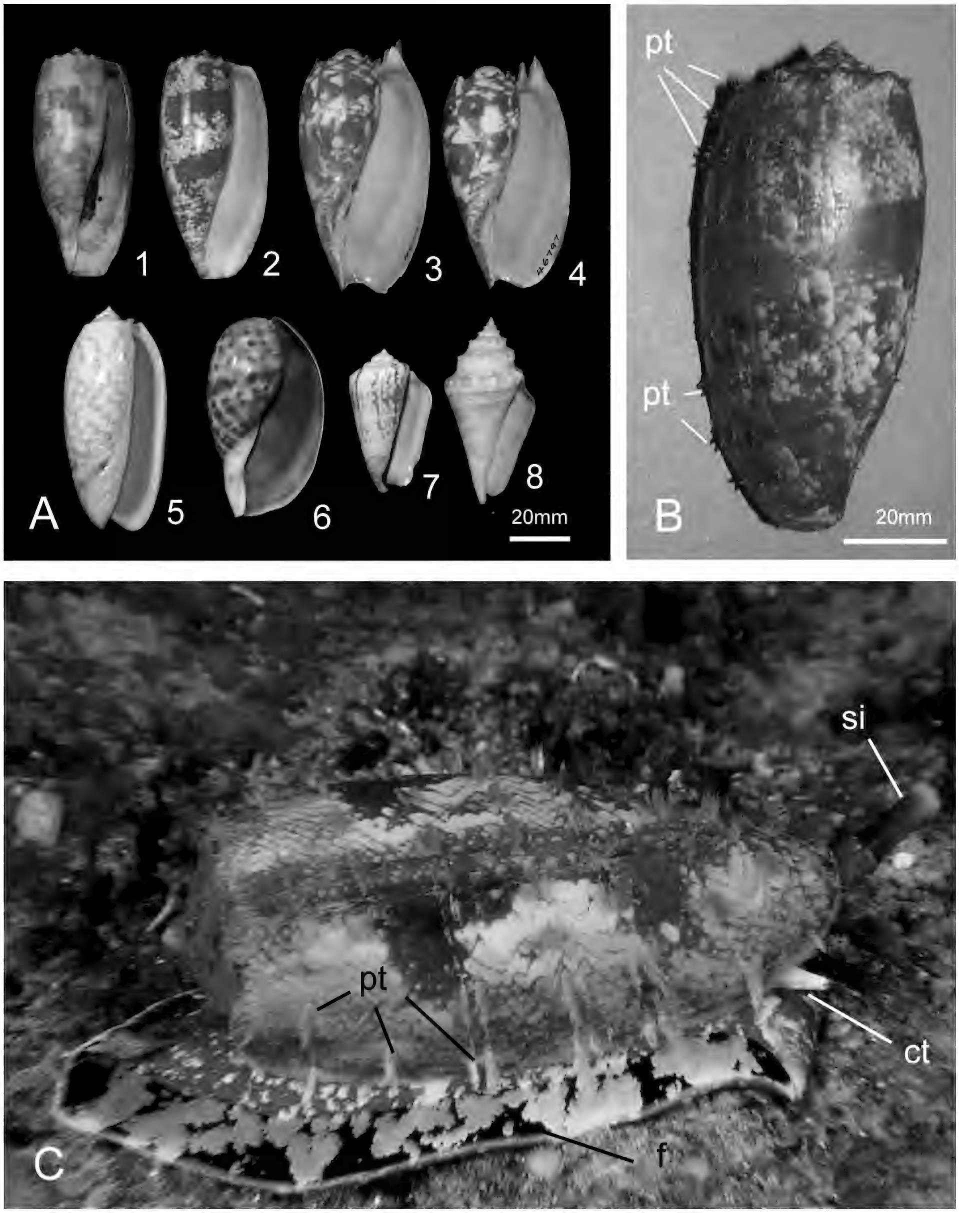


FIG. 7. **A,** Shells of *Conus geographus* shown alongside those of harmless reef gastropods which could potentially be mistaken for cone snails. (1,2) *Conus geographus* (Garbutt case shell from Hayman Reef (1) (QMMO1689); another Hayman Reef specimen (2) (QMMO81326)); (3,4) Juveniles of the volute *Melo amphora* (Volutidae); (5) Olive snail *Oliva seriacea* (Olividae); (6) Juvenile (bulla stage) of tiger cowrie *Cypraea tigris* (Cypraeidae); (7) Juvenile red-mouthed stromb *Conomurex luhuanus* (Strombidae); (8) Juvenile of common spider shell *Lambis lambis* (Strombidae). **B,** *Conus geographus* shell with dried periostracal tufts arranged in rows (arrows) (QM specimen, Rainbow Channel, North Stradbroke Island, QMMO81323). **C,** Crawling specimen of *Conus geographus*, 10 metres, Milne Bay. Note periostracal tufts (pt), foot (ft), cephalic tentacle with eye (ct), siphon (si), proboscis sheath (with contained proboscis) (ps). (Images: A,B, J.M. Healy, Queensland Museum; C, Neville Coleman Slide Collection (Queensland Museum).

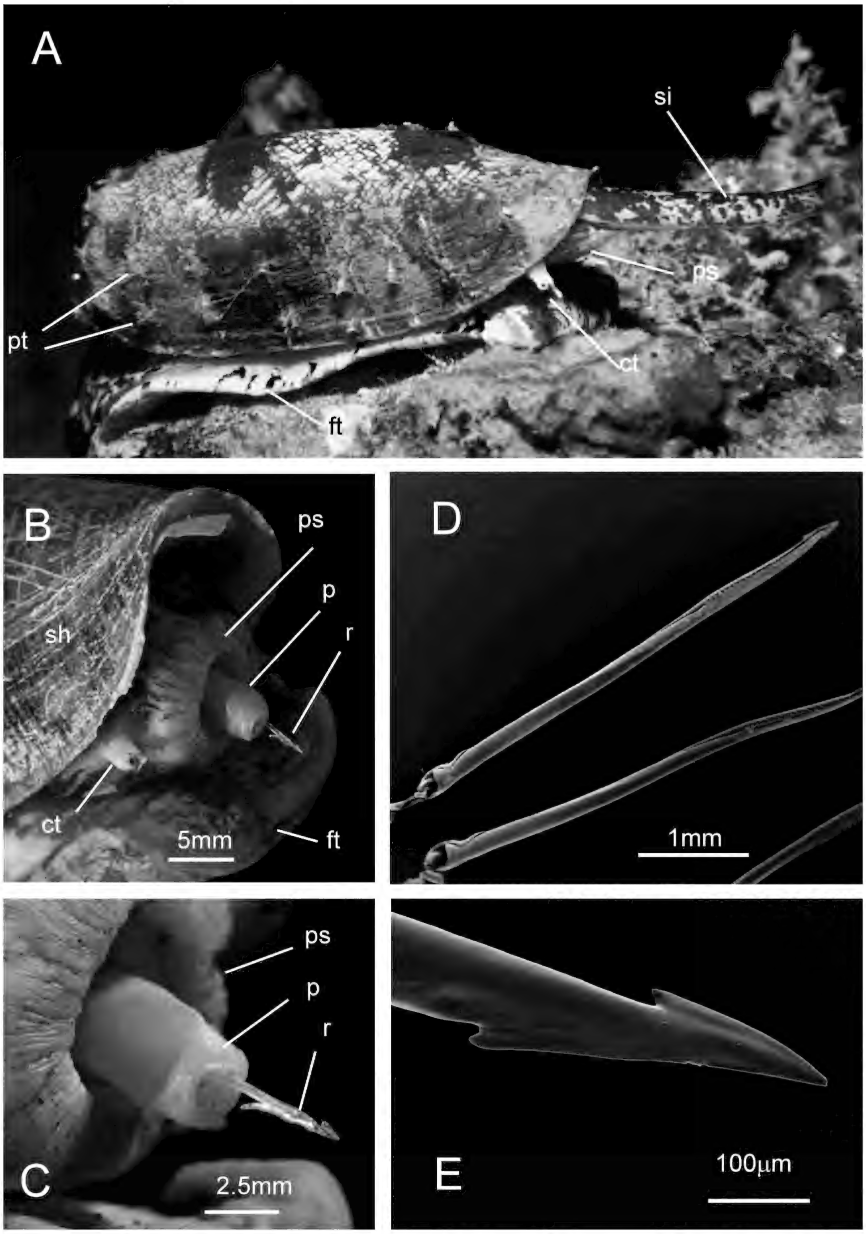


FIG. 8. **A,** *Conus geographus* crawling. Note periostracal tufts (pt) (and significant area of missing periostracal covering), foot (ft), siphon (si), cephalic tentacle with eye (ct), proboscis sheath (ps). **B,** Emergent radular tooth (r) in preserved specimen of the fish-eater *C. striatus* shown in relationship to the foot (f), proboscis (p), proboscis sheath (ps), cephalic tentacle and eye (ct) and anterior region of shell (sh) aperture. **C,** Detail of emergent radular tooth (r) of *C. striatus* (note barbed tip) in relation to proboscis (p) and proboscis sheath (ps), **D,** Scanning electron micrograph (SEM) of two entire radular teeth of fish-eater *Conus tulipa* showing barbs (on tip) and small serrations on anterior portion of shaft (ex QMMO85908, Bloomfield Reef, Great Barrier Reef). **E.** SEM detail of barbs of radular tooth of *C. tulipa* (same source as Fig. 8D). (Images: A-C, Clay Bryce, Western Australian Museum; D,E, E. Lovas, University of Queensland (Healy and Lovas unpublished).

of his eyesight being affected. He gradually became drowsy, a condition explained by the owner of the launch as being very similar to that caused by snake-bite. He was walked about, and attempts made to prevent him from lying down, but as the drowsiness became worse, it was decided to take him to the mainland, a distance of 18 miles, which was covered in about 1½ to 2 hours, but by the time the mainland was reached, the patient was in a coma. There appeared to have been no distressing symptoms, beyond the drowsiness and the first pain when the animal struck his hand. The patient was landed at Cannon Valley and taken by, it is understood, an ambulance to Proserpine, but died before he reached the district hospital there. The deceased was in his early twenties. Mr. Jamieson said he irritated a similar Cone shell himself afterwards, and it discharged a loose sharp-pointed dart, which was transparent and had a small sack filled with yellow matter at the base. Mr. Jamieson in a letter to me stated that there was a gradually increasing dullness of sight attended by numbness of the jaw muscles extending slowly to the rest of the body. There was very little pain in the region of the sting (the centre of the palm of the hand). His symptoms became alarming about an hour after the sting, though noticeable half an hour earlier. He was semi-conscious and very weak in two and a half hours and completely unconscious in three to three and a-half-hours, gradually weakening till death about four and a half hours after being stung. His friends told Mr. Jamieson that he had been subject to "turns" without apparent cause, showing much the same symptoms in a lesser degree on two previous occasions, and for this reason little notice was taken of his condition until it became alarming.' "

Comments. A few details from this account are clearly not correct such as the assertion that the envenomation had occurred while on the reef-walk (it had occurred on the boat after the reef-walk and in fact after lunch) and Garbutt's age being said to be 'early twenties' (he was actually 27). However aside from these errors, it is of considerable importance to learn that Garbutt had been known by his trip companions to suffer 'turns' with "much the same symptoms" on "two previous occasions". No doubt this propensity for sudden ill-health, and the apparently mild initial effects of the 'sting', had led all on board the boat to not at first regard the stinging as life-threatening, and hence the long delay (1-1½ hours) in beginning the voyage to the mainland and medical help. This information also fits with T.B. Clouston's comment to J.B. Henderson (Queensland Government Analyst) (26th June, 1935) that Garbutt's friends had initially "laughed at him" before realising the seriousness of the situation. We do not know the nature of Garbutt's previous 'turns' or where they occurred. Possibly he had a pre-existing but undiagnosed cardio-vascular condition, epilepsy or had a hyper-allergic reaction to what was already a potentially lethal venom, any one of these problems could have rendered the cone snail 'sting' fatal. That Garbutt had apparently shown essentially the same symptoms on two previous occasions begs the obvious question - had he been stung by cone snails before ? (and we know from Jamieson's coronial statement that Garbutt had also visited Hayman Island in 1934 – was this one of those occasions?). Jamieson's comment that he had later induced a 'similar cone shell' to eject a sting (with venom) is also of interest as it helped him confirm Garbutt's claim of having been 'stung' by a marine snail. However, this experiment was not mentioned in his coronial statement, nor indeed was the revelation about Garbutt having been subject to 'turns' mentioned by Jamieson, Breen or Gray in any of their statements. As to what cone species Jamieson had prodded is not known. The word 'similar' is too vague to draw any conclusions from, although the fact that Jamieson could actually see the radular tooth in his specimen suggests it would likely be a species known to have long radular teeth. This would include *C. geographus* (13 mm – Dutertre *et al*. 2016), *C. textile* (8-10 mm – Shaw, 1914; 15 mm – James, 1980;) and *C. striatus* (10.6 mm – Kohn, 1956; 13.3-15.1 mm - Franklin *et al*. 2007) but probably exclude *C. tulipa* (4 mm - Shaw, 1914; present study – see Fig. 8D,E) or any of the large vermivorous cones (e.g. *C. virgo* (1.7-2.4 mm), *C. leopardus* (0.7-1.6 mm) – Franklin

et al. 2007). While it is entirely possible that a second specimen of *Conus geographus* was collected by the reef-walking party, it seems more likely that Jamieson had been handling a specimen of the much more common *C. textile* or *C. striatus*, the latter not dissimilar in shell shape and mottling to *C. geographus* (see Fig. 8B, C for the protruding radula tooth in *C. striatus*). There is, however, no reason to doubt that the specimen of *C. geographus* in the Queensland Museum (QMMO1689) which had been sent by Clouston to Henderson and thence by Henderson to Longman at the Queensland Museum is indeed the specimen responsible for the fatality.

Conus geographus - deadliest of the Conidae

Of the 133 species of Conidae occurring in Queensland waters (Jon Singleton, pers comm, 2009,) at least 85 can be found on the Great Barrier Reef and its associated islands (based on Queensland Museum collection holdings). Jarrett (2011) records 39 species of *Conus* from the Whitsunday Islands. The Queensland Museum has specimens of several of these species collected from Hayman Island Reef (Fig. 1) including *Conus geographus*, so it could be said that the chances of finding at least one live cone snail on a reef walk at that particular locality are good. However, *C. geographus,* despite having a very wide range throughout the Indo-West Pacific and frequently seen in collections, is not considered a particularly common species at any given locality (including the Whitsunday Islands – see Jarrett, 2011). In addition, the shell of this species being almost cylindrical in shape, frequently thin (solid usually only in large, old adults) and with a very wide aperture, certainly does not look like a typical 'conical' species of Conidae (Fig. 1). Specimens could easily be mistaken by a non-expert for a number of harmless and unrelated snails such as juvenile baler volutes (*Melo* spp), olives (*Oliva* spp), certain strombs, or 'bulla stage' juveniles of large cowries such as *Cypraea tigris* (for a visual comparison of these see Fig. 7A). Some newspaper reports on Garbutt's death suggested that he may have been drawn to collect the cone specimen because of its allegedly beautifully-patterned shell. While it is true that shells of many species of Conidae do exhibit colours and/or patterns that are eye-catching (e.g. *C. textile*, *C. marmoreus* – see Fig. 1) the same cannot generally be said for *C. geographus*, with its camouflage-like pattern of mottled brown or reddish-brown, interspersed with irregular white patches composed of tiny triangles (Figs 1A, 7B, C 8A, 9B). By contrast, the animal of *C. geographus* (Figs 7C, 8A), particularly the large foot, is considerably more attractive than the shell, so it is entirely possible that the sight of a crawling specimen may have caught Garbutt's attention.

Conus geographus is a well-documented fish-eater and the most injurious to humans of all Conidae species (Endean & Rudkin, 1965; Yoshiba, 1984), with 60 envenomations and 26 confirmed fatalities ascribed to it (Kohn, 2016). It is mostly a night-time feeder like other cones, especially on incoming tides, and is usually found on or under rocks, coral slabs or rubble during the day (Coleman, 1975, 1999, 2003; Röckel *et al*. 1995; Jarrett, 2011; Queensland Museum collection records). The feeding strategy of *C. geographus* and related species such as *C. tulipa* has been termed 'net –feeding' or 'net-engulfment' and involves the animal first expanding its proboscis sheath into a broad, trumpet-shape as it homes in on the target fish (chemosensory), and then emitting a squirt of venom (containing an insulin) from the proboscis to partially stun the intended prey (Olivera *et al*. 2015). Once the fish is enclosed by the now capacious proboscis sheath it is then envenomated and consumption begins (Johnson & Stablum, 1971; Cruz *et al*. 1978; Yoshiba, 2002; Olivera *et al*. 2015, 2017). According to Johnson & Stablum (1971), if the shell of living *C. geographus* in shell size range 50-87 mm (subadult) is subjected to external pressure or is damaged, the proboscis immediately extends towards the affected area. They concluded that the animal is, in such circumstances, acting primarily defensively (i.e. it assumes it is being attacked). Endean & Rudkin (1965) noted that specimens of *C. geographus* subjected to such external pressure exuded venom from the proboscis tip followed by a radular tooth.

Dutertre *et al*. (2014) have even argued that the aggressive nature and high potency venom (to humans) of *C. geographus* and *C. tulipa* are direct evolutionary responses to the weak protection offered by their light and thin shells. Hence it is obvious that any prolonged or vigorous handling of a living specimen - as occurred in the Garbutt case - would create a potentially dangerous situation. The harpoon-shaped, anteriorly-barbed, radular teeth of *C. geographus* (Endean & Rudkin 1965; Thompson & Bebbington 1973), like those of other conids, are hollow to maximise transmission of venom through the wound entry (see Fig. 8B-E for teeth of *C. striatus* and *C. tulipa*), and at 13 mm in length are among the longest of the Conidae (see Dutertre *et al*. 2016 for SEM image of entire tooth of *C. geographus*). The primary venom components or 'conopeptides' of *C. geographus* act as a powerful neuromuscular toxin disrupting normal nerve and muscle activity (usually blocking ion channels or neurotransmitters), thereby inducing a wide range of effects on humans including numbness, drowsiness, muscle paralysis, breathing or swallowing difficulties, blurring or loss of vision and if medically untreated can lead to a comatose state and ultimately even death (Endean *et al*. 1974; Yoshiba, 1984; Bingham *et al*. 2010; Dutertre *et al*. 2014; Halford *et al*. 2015; Kohn, 2016, 2018). Variation in response to *C. geographus* envenomations is considerable ranging from relatively mild pain and prolonged dizziness for adults (e.g. Kenworthy 1970) to sharp pain and almost instant death, particularly in infants (Kohn, 2016) and it would appear that survival may be due to a range of factors such as the age, fitness and individual reaction of the victim, size of the cone specimen, strength and chemical profile of the delivered venom dose and access to appropriate medical attention (Bingham *et al*. 2012; Dutertre *et al*. 2014; Halford *et al*. 2015; Kohn 2016, 2018). As was the case with Charles Garbutt, prolonged agonising pain is usually not experienced by victims of *C. geographus*, contrasting with the sometimes intense local pain often associated with wounds from molluscivore species such as *C. textile* and *C. marmoreus* (Kohn 2016). Based on an estimate of Garbutt's probable weight range, and the known shell size of the fatal cone specimen, Dutertre *et al*. (2014) have concluded that he was killed with a venom volume of 32 µl and lethal dose of between 0.029-0.038 mg/kg. Research on *C. geographus* has demonstrated differences in the conopeptide profiles of venom from the venom duct and that collected by milking (i.e. via provocation of the snail to sting) (Bingham *et al*. 2012; Dutertre *et al*. 2014) and with this in mind it appears highly likely that Garbutt was subjected to a defensive rather than prey-oriented envenomation. The fact that he survived almost five hours after being stung without proper medical attention was no doubt a testament to his fit condition (he was a footballer and almost always in good health according to his friends).

In shells of live-collected *Conus*, an organic 'skin' called the periostracum is present, as it is in the majority of other externally-shelled molluscs. This is actually the outer layer of the shell but remains uncalcified and can obscure the underlying pattern/ colour of the calcareous part of the shell. Often the degree of obscuring is slight (*C. textile, C. marmoreus, C. eburneus*) but sometimes can be substantial or even total (*C. virgo, C. terebra*) (pers obs). The periostracum may be partially or even almost completely eroded from very mature Conidae specimens, and most collectors tend to regard the 'skin' as unsightly and clean it from the 'hard' shell with household bleach. In *C. geographus* the periostracum is mostly thin and the underlying shell pattern still visible. However one notable feature of the periostracum in this species, and best developed and usually intact in juveniles and subadults, is the presence of rows of periodically spaced tufts which, to the casual observer can give an impression of encrusting algae, hydroids or sponges (Figs 7B,C, 8A; for other images see also Concar, 1996; Olivera *et al*. 2015). This 'tufted' style of periostracal ornamentation is also seen in another fish-eater *Conus tulipa* (pers obs) as well as a number of worm-eaters (e.g. *C. capitaneus*, *C. miles*, *C. distans* – Coleman, 2003; pers obs). While the periostracum helps to protect the calcareous portion of the shell from erosion (chemical or physical) and almost certainly also from

fowling by oysters or barnacles (which would potentially hinder or even prevent continued shell growth) the purpose of the periostracal tufts appears less uncertain. They may well provide camouflage if the resemblance to epibionts is viewed as a plausible explanation. One can easily appreciate why Charles Garbutt set to work trying to scrape off the periostracum in order to enhance the appearance of his 'lucky' find. Such handling, without very thick gloves, would have easily triggered a defensive and unfortunately effective strike by his *C. geographus* specimen.

To what extent was Charles Garbutt a victim of ignorance about the specimen he collected and handled and which would ultimately claim his life? In 1935 no popular book on tropical Australian marine molluscs or their shells was available nor would one be until the appearance of Joyce Allan's 'Australian Shells' in 1950. Aside from museum or natural history society field activities, shell collecting in Australia in the 1930's was not widespread or scientific and most often limited to those seeking mementos of their travels. Although the danger of cone snails was documented in the scientific literature from the 19th century onwards (e.g. Cox, 1885; Bergh, 1895; Shaw, 1914), the subject was only occasionally mentioned in works designed for public consumption such as newspapers, encyclopaedias or travel-oriented books such as S. E. Napier's popular *'On the Barrier Reef'* (1929, reprinted six times in the 1930's). Two of the three coronial statements from *'Cheerio'* travellers (those of Joseph Breen and Robert Gray, given on 13th August 1935 – see Appendix 2), claimed that Garbutt referred to his specimen as a 'cone shell', indicating that he knew what a 'cone shell' was, but whether he could actually distinguish cones from other marine snails and at the same time not be aware of their potential hazard, we do not know. Interestingly, Breen, in a newspaper interview given over six weeks before his coronial statement, recalled Garbutt as having said "this *shell* stung me" [present author's emphasis] and Bruce Jamieson, in his coronial statement from the 3rd of July (see Appendix 2) recalled Garbutt saying "Bruce, this darn *thing* stung me" [present author's emphasis], thereby hinting that Garbutt did not, in fact, know that he had collected a cone. The apparent abandon he exhibited when 'cleaning' his specimen on the deck of the *'Cheerio'* and later provoking the animal with a fish hook after he had already been stung, clearly indicate that he was oblivious to the danger and therefore not truly knowledgeable about cone snails, as for example, an experienced marine biologist or seasoned shell-collector would have been. Jamieson and Garbutt's travelling companions, by not saying anything to him while he was scraping his specimen, were either negligent, or much more likely also ignorant of the danger posed by such vigorous handling of cone snails.

The Fatal Specimen

The specimen of *Conus geographus* accepted as being responsible for the death of Charles Garbutt is today housed in the dry shell collection of the Queensland Museum (QMMO 1689) (Figs 9, 10A, B). It consists of the shell (length 84 mm, maximum width 34 mm) and its enclosed, but dried animal. The accompanying label (Fig. 9A) leaves no doubt as to the provenance of the specimen and it is clearly the same specimen shown photographically in an article in the *The Townsville Bulletin* (29th June, 1935, p. 7) (Fig. 5A). The slightly faded colours of the shell and the somewhat powdery inside surface of the shell aperture (Fig. 9C) are suggestive of long term exposure to preservative, initially possibly formalin, followed by storage in ethanol. Queensland Museum volunteer Mrs Thora Whitehead (pers comm, 19th Dec, 2018 and 27th May, 2020) recalled that when she located the specimen in the collection in the late 1980's, it was stored in ethanol (with its label), and that a decision was taken to have it dried out, undoubtedly to ensure preservation of the thin (sub-adult) shell.

From T.B. Clouston's letter of the 26th of June to J.B. Henderson (Queensland Government Analyst) we know that the specimen was still alive on that day (i.e. the day after the fatality). Hence it would have been Clouston who originally preserved the specimen, either in

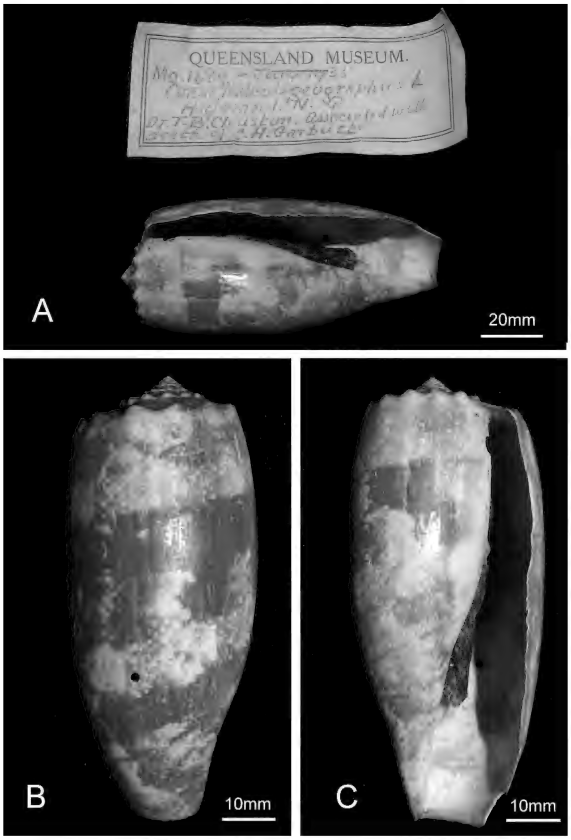
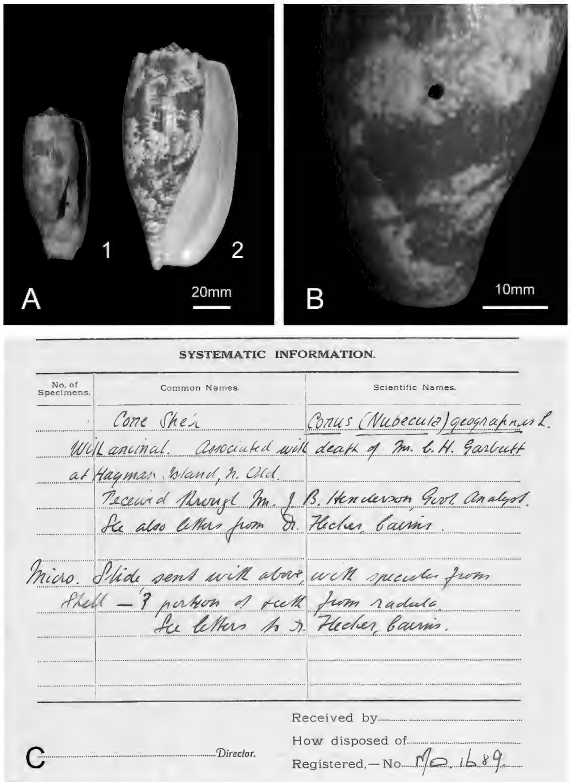


FIG. 9. **A,** The fatal specimen (sub-adult, length 84 mm) of *Conus geographus* (QMMO1689) shown with original Queensland Museum label (probably in Director Heber Longman's printed hand) and with dried, apparently intact, animal within shell. **B,** QMMO1689, dorsal aspect. Note the drill hole which is almost certainly artificial and probably intended for a string-tied label. **C,** QMMO1689, apertural (ventral) aspect of the shell and dried animal. (Images: J.M. Healy, Queensland Museum).

formalin or alcohol (both of which would have been available at the hospital), in order to send it to Henderson for examination. We also know from Clouston's letter that he prepared "a sting from the cone-shell fish (between two slides)". Unfortunately, this slide, although definitely received by the Queensland Museum from Henderson and registered as 'MO 1670' is not included in the museum's current database and probably lost. It is specifically mentioned by Longman in a reply to Clouston (20th July, 1935) and on the donor schedule form and the Mollusca Collection Register – see Fig. 10C) also in Longman's hand. Mrs Whitehead recalled that a slide was said to have existed but she had never seen it nor could she find it in the dry or wet sections of the Queensland Museum Molluscan Collection in 1986. According to the relevant entries in the Collection Register, the slide was placed with the 'Molluscan Slides', the whereabouts of these today being unknown. From Longman's 20th July letter to Clouston, we know that he had personally examined the slide and considered that the mounted specimen did not look like published illustrations of *Conus* radular teeth (at least in the literature available to him at the museum). Given Longman's dependability as a zoologist and the fact that he had at least some access to relevant literature depicting *Conus* radular teeth, it is possible that Clouston may have placed some other piece of tissue on the slide. However, Longman openly admitted that the Queensland Museum had no particular expertise on the subject of *Conus* radular morphology, and it is now known that *Conus* teeth, while all 'harpoon-shaped' do differ in structural details between species (James, 1980; Kohn *et al*. 1999; Nishi & Kohn, 1999; Franklin *et al*. 2007). Radular teeth of *C. geographus* are particularly long (13 mm) and slender compared to most species (Endean & Rudkin, 1965; Dutertre *et al*. 2016). Descriptions of the 'sting' from the Hayman Island specimen as being hair-like and about half an inch long, are consistent with the known length and shape of the *C. geographus* radular teeth suggesting that Clouston's slide did indeed contain a radular tooth.

In the Louis W. Borserini photograph published in *The Townsville Bulletin* article of the 29th June (see Fig. 5A), the *C. geographus* specimen is looped either by string or more likely a rubber band around its mid-section, possibly to prevent the animal emerging to extend its proboscis. The same image (with vestas/matches tin cropped out), plus an additional image showing a dorsal view of the specimen (but with the tin's brand name photographically removed), appear in Hugo Flecker's paper on the fatality



SYSTEMATIC INFORMATION.

No. of Specimens.	Common Names.	Scientific Names.
	Cone Shell	Conus (Nubecula) geographus L.
With	animal. Associated with	death of Mr. C.H. Garbutt
at	Hayman Island, N. Qld.	
	Received through Mr. J.	B. Henderson, Govt. Analyst.
	See also letters from Dr.	Flecker, Cairns.
Micro.	Slide sent with above,	with specula from
Shell	– ? portion of teeth	from radula.
	See letters to Dr.	Flecker, Cairns.

Received by
How disposed of
Director.
Registered,—No. Mo. 1689.

FIG. 10. **A,** *Conus goegraphus*. Comparison of QMMO1689 (1, length 84 mm) with an adult specimen (2, length 120 mm) (QMMO81325, reef off Cooktown). **B,** Detail of the hole drilled into dorsal surface of QMMO1689, probably by Queensland Government Analyst J.B. Henderson. **C.** Extract from Queensland Museum Donor's Schedule from 22nd July 1935 showing the receipt (in Longman's hand) of the specimen of *Conus geographus* (with animal) which had been retrieved by Dr T.B. Clouston and forwarded by him to J.B. Henderson. This specimen and a microscope slide said to contain a 'sting' (radular tooth) from the animal were registered as 'MO 1689' and 'MO 1690' respectively. Only the shell and its contained dried out animal now survive. (Images J.M. Healy, Queensland Museum).

and other known cone snail envenomations, published in the *Australian Medical Journal* (Flecker 1936). [Although not credited by Flecker, this second photo is undoubtedly another of Borserini's]. The shell pattern seen on specimen QMMO1689 in the Queensland Museum leaves no doubt that the images from *The Townsville Bulletin* article and Flecker's paper are of this specimen. Inspection of the shell surface of QMMO1689 reveals that the periostracum does appear to have been scraped off (Fig. 9B,C), which correlates with two eye-witness accounts (Bruce Jamieson and Joseph Breen) of Garbutt scraping the surface of the shell to clean it, apparently while it rested in the palm of his left hand (and using a fish scaler according to Jamieson). It was this unfortunate act that allowed the living cone snail to inject its venom into Garbutt's hand.

Aside from a noticeable chip on the anterior edge of the aperture, the shell today is as seen in the aforementioned *The Townsville Bulletin* article (1935) and in Flecker's 1936 paper and most recently in Dutertre *et al.* (2016). However, when the present author examined the shell a small round hole (diameter 1.6-1.8 mm) was observed on the dorsal surface of the last whorl of the shell, which had at first not been obvious as it was filled with dirt (Figs 9B, 10B). Although at first glance the hole appears to be circular, it is not precisely so, and its presence is at first puzzling. The only contemporary image of the shell viewed from the dorsal perspective is that previously mentioned (see Flecker, 1936, p. 465). Unfortunately this dorsal view photograph (from June 1935), as reproduced by Flecker, is not of high enough resolution to determine if the hole is present or not, and sadly the whereabouts of the original Borserini photographs are unknown and therefore cannot be checked. Nevertheless, two explanations for the hole seem possible: either (1) it is the result of a predatory attack on the specimen by shell-drilling gastropods such as murex snails (Muricidae) or sand snails (Naticidae) or by shell-drilling octopods or (2) it was artificially created. Was Garbutt's attention drawn to the cone snail by the sight of it being preyed upon ? Close inspection of the hole in the specimen (see Fig. 10B) shows that it is not consistent with muricid or naticid drill holes (Kowalewski 2004; Morton 2005; pers obs) which are very precise and neatly made, nor does the hole conform to those produced by an octopod, which are usually ovate or angulate (rarely circular) and often crudely drilled (Pilson & Taylor 1961; Arnold & Arnold 1969;

Nixon 1980; Nixon *et al*. 1980; Hiemstra 2015; pers obs). Given that Clouston forwarded the specimen to J.B. Henderson (the Queensland Government Analyst) for study, it seems likely that either Clouston or Henderson - probably the latter - drilled a hole through the shell for attachment of a label (via wire or string) to the wet-preserved specimen. Henderson may have done this in anticipation of the specimen later being required as evidence, but if so, any string or associated label does not survive today (the only label with the specimen is the Queensland Museum label written by Longman in 1935 –see Fig. 9A). It is surprising that the specimen was never sought by the Coronial Inquiry given that it was directly responsible for Garbutt's death and that this was the first time such a fatality had occurred in recorded Australian history. Henderson forwarded the specimen and Clouston's microscope slide (said to contain a mounted radula tooth) to the Queensland Museum on the 12th of July, as per Clouston's instructions and in exchange for a formal identification of the species. Even though the Coronial Inquiry had begun on the 3rd of July, it did not seek evidence from two of the key eye-witnesses (Breen and Gray) until the 13th of August, hence the specimen, identified by Longman in late July, would certainly have been available for Court reference if sought.

The size of the Garbutt case specimen (84 mm) is probably average among those encountered by most collectors but not considered large. The specimen is also thin and lacks any thickening of the outer lip and is here considered sub-adult. *Conus geographus* is known to grow to a shell length of 166 mm (Rockel *et al*. 1995), and the largest specimen in the Queensland Museum measures 120 mm (Fig. 10A).

Finally, some confusion exists in the literature concerning the specimen responsible for the fatality (QMMO1689). Halford *et al*. (2015) have stated that the photograph of a specimen of *C. geographus* shown in their Table 1 is QMMO1689, and that the present author supplied the photograph. This is not correct. The present author did supply images of QMMO1689 but these were not used in the Halford *et al*. paper: instead those authors appear to have photographed one of their own specimens (possibly from the Philippines or Boult Reef, Great Barrier Reef as listed in their Table 1 for material examined). Certainly the photograph in Halford *et al*. (2015) does not correspond with any specimen of *C. geographus* in the Queensland Museum Collection. QMMO1689 is however illustrated in Dutertre *et al*. (2014).

The Garbutt Fatality: A Reconstructed Account

What follows is a reconstruction of the events of 25th June 1935 that led up to Charles Garbutt being stung by *Conus geographus* at Hayman Island, then the subsequent efforts made to transport him to Proserpine District Hospital for medical attention and finally the aftermath of the fatality including press coverage, the Coroner's Inquiry and scientific interest in the case. It is based on all sources of information available to the author including contemporary newspaper articles, letters in the Queensland Museum archives, the official coroner's report (held in the Queensland State Archives) and other sources. Fortunately, these sources have enabled a unified narrative to be established but in a few details it has been necessary to apply a best-fit process or even reject some published assertions when the evidence demands it.

Charles Hugh Garbutt, one of the five children of John and Margaret Garbutt of Townsville, had moved to Ayr apparently some time either in 1934 or early 1935 and worked there at a motor vehicle dealership. An enthusiastic footballer, he was very well-liked in both the Ayr and Townsville communities. [The Garbutt family was one of the most prominent in Townsville, having made their money in cattle and the associated meat trade, and is today celebrated in the Townsville suburb of Garbutt]. On Thursday the 13th of June, he and a group of 10 other men (many or possibly all of whom were friends), travelled by train from Ayr to Bowen, where on the morning of the 14th the party embarked on a two week fishing/recreational cruise of the Whitsunday Islands on board the auxiliary (motor and sail) launch '*Cheerio*', captained by owner (Robert) Bruce Jamieson. The cruise was to leave Bowen, then

head for the Whitsunday Group and finally return to port in Mackay. On Tuesday, the 25th the launch had made its way to Hayman Island, anchoring at Hayman Island Reef (off the south-east shore of Hayman Island) towards midday or soon after (recollections differ). As this coincided with low tide, a decision was made for the group to go on a reef walk, partly with the intention of gathering shells. At about 1.30 pm they returned to the *'Cheerio'* for lunch, with everyone leaving their shells on deck for later sorting. Jamieson remembered Garbutt showing him a shell that he had found on the reef walk and that he had started cleaning the outside of it with a fish scaler before then going to lunch with the other passengers. Joseph Breen, in is coronial statement some weeks after the event, recalled Garbutt proudly saying to him "I've found a cone shell, I'll show it to you after lunch". According to Breen, Garbutt was first to finish his lunch and evidently in a hurry to get back to his shells on deck to further examine and clean them. At around 2.30 pm Jamieson remembers that Garbutt came up to him, showed him the shell and stated "Bruce, this darn thing has stung me" then displayed the palm of his hand which now had a small puncture wound. Jamieson suggested that Garbutt get some tobacco from one of the smokers on board and rub it into the wound, probably hoping that the nicotine might in some way ameliorate the discomfort. Robert Gray, who was seated on the deck at the time, remembers hearing Garbutt exclaim "I've been stung by a cone shell". Breen and Robert Gray were also shown the wound, the effects of which by now had started to numb the affected (left) hand. Garbutt, apparently more annoyed than concerned by what had happened, then tried to demonstrate to Breen, Gray, Jamieson and probably others on deck exactly how he had been stung by trying to provoke another attack from the snail using a fish hook. This resulted in another 'sting' poking out from the proboscis which, according to Jamieson looked like a "needle like white spike". Feeling decidedly unwell Garbutt subsequently sat down on the steps of the wheelhouse and put down the cone specimen. Evidently some attempt was made to walk him around the ship, possibly to prevent him from passing out, but it was clear that he was losing control of his limbs and becoming increasingly drowsy. About 20 minutes after being stung (i.e. 2.50 pm) his lips and jaw muscles began to go numb, and about 3.00 pm his eyesight deteriorated to the point of double vision and inability to discern distant objects (according to Gray, Garbutt's eyes had glazed over). Breen and Gray, who had, like others on board, not at first taken the matter very seriously, now realised that the situation was real and worsening. They took their friend below deck and Breen gave him a nip of brandy to ease the distress, and around 3.30 pm skipper Jamieson called in to check how things were going. The *'Cheerio'* had been sailing around Hayman Island after lunch and was now anchored at the island. Garbutt's fast deteriorating condition (legs now paralysed and the beginnings of unconsciousness evident) convinced all on board that the vessel had to up-anchor and make its way at full speed to Cannon Valley (the present day town of Cannonvale) to get medical attention. Even at top speed (9 knots or 16.6 km/hr) the journey to Cannon Valley from Hayman Island (a distance of 32.2 km or approximately 20 miles) would take two hours, during which time (around 4.30- 5.30 pm) Garbutt gradually slipped into total unconsciousness.

The *'Cheerio'* arrived at Cannon Valley – presumably at or near Cannon Valley Beach - just after dark at about 6.00 pm and no time was wasted in telephoning the Proserpine District Hospital (and Dr Thomas Clouston), explaining that a man had been stung by a shell fish and was in a serious condition. To minimise any delay in reaching medical help it was requested that the ambulance meet the lorry that was about to leave Cannon Valley for the hospital. Clouston immediately telephoned Robert Bartlett of the Proserpine Ambulance Centre asking him to first pick him up then head for Cannon Valley to meet the lorry conveying the patient. *'Cheerio'* skipper Jamieson had enlisted the assistance of Alex Altmann who operated a lorry (and maintained a medical kit for the hospital), and asked if he could take the unconscious Garbutt to meet the ambulance

along the Proserpine to Cannon Valley road. This was fortuitous as Altmann had already been ready to leave for Proserpine and was now pulled up on the beach to make the transfer of Garbutt to the vehicle easier. Gray and Breen helped to get Garbutt on board the lorry and were to accompany him on the journey along the Cannon Valley to Proserpine road (which, unfortunately for Garbutt, was a rough and unsealed road). The ambulance met the lorry at about 7.00 pm about half way along the Cannon Valley to Proserpine road, or approximately 11.3 km (7 miles) from the hospital. Clouston examined his patient and learned that he was 'Charles Hugh Garbutt' and then explained to Breen and Gray that the situation was indeed grave. Garbutt's pulse was weak, his respiration shallow and his eyes had dilated pupils and exhibited no corneal response. After Garbutt had been taken on board the ambulance, apparently accompanied by Breen, Clouston then asked Bartlett to proceed to the hospital as quickly and as safely as possible. On reaching the hospital at about 7.30 pm Clouston left the ambulance and made for the surgery presumably to make preparations for a possible procedure. Bartlett then noticed that Garbutt's pulse had collapsed. When the doctor returned he was told by Bartlett what had happened. He re-examined Garbutt and pronounced him deceased. Bartlett then conveyed Garbutt's body to the hospital morgue. The remainder of the *'Cheerio'* touring party and vessel skipper Jamieson at Cannon Vale were subsequently informed of the news by telephone. The following morning (Wednesday 26th June, 1935) Clouston performed the post-mortem in the presence of Police Constable David McQuaker and issued him with a Post-Mortem Certificate noting that the death of Charles Hugh Garbutt was caused by (1) sting from a cone shell fish; (2) acute toxaemia and (3) cardiac failure. Clouston took stomach tissue samples for chemical analysis but otherwise noted that Garbutt was in fine physical condition. The doctor had also secured the specimen of the cone snail that had inflicted the injury and made a slide preparation of the 'sting' (radular tooth) which he had taken from the living specimen on the day of the post-mortem. Clouston wrote to the Queensland Government Analyst in Brisbane (J.B. Henderson) on that day (26thJune), giving details of the post-mortem and his conclusions as to the cause of death. Along with his letter he also forwarded to Henderson the cone specimen, undoubtedly preserved in alcohol or formalin for posting, as well as the prepared microscope slide containing the 'sting' and tissues samples from the stomach for analysis. Photographs of the cone specimen were taken by Louis W. Borserini, an honorary bearer of the Proserpine Ambulance, either on the 25th June or on the 26th June when the specimen and slide were dispatched to Henderson. Henderson examined the tissue samples provided by Clouston and wrote back to him on the 6th July to say that no alkaloids were detected and to agree with the doctor's post-mortem conclusions. Henderson then forwarded the preserved cone specimen and slide to the Director of the Queensland Museum, Heber Longman, and these two items were then duly registered as 'MO. 1689' and 'MO. 1690' respectively (the current whereabouts of the slide remain unknown).

Several funeral notices were published in local papers on the 27th of June, and on that day Charles Garbutt was laid to rest at Belgian Gardens, West End (Townsville). Press coverage of the death was considerable both within Queensland and elsewhere around Australia although confusion as to the exact identity of cone snail involved would continue for some time (the species was initially believed to be *Conus textile* but later shown to be the much less common *C. geographus*). A Coronial Inquiry into Garbutt's death, headed by Charles A. K. Morrison, commenced on the 3rd of July at Proserpine Coroner's Court. Statements were taken from Constable David McQuaker, Proserpine Ambulance Superintendent Fred Bartlett and the *'Cheerio's'* skipper Bruce Jamieson. The court then adjourned on the 5th of July until the 13th August when at the Ayr Coroner's Court (headed by A.M. Taylor) statements were obtained from *'Cheerio'* party members Joseph Breen and Robert Gray. The inquiry adjourned to Proserpine court where it was officially closed on the 15th August. No

suspects or suspicious circumstances were identified and the suspected cause of death was given as "sting from a cone shell fish". The press reported these findings as well as many of the witness statements.

How do surviving recollections of the fatality compare ?

Although awareness of the Charles Garbutt case in the Australian community would be low today, the few family recollections of it that I have been able to trace have, perhaps surprisingly, accurately preserved most of the key elements of the story. Ken Glasheen (a nephew of Charles and the closest surviving relative) recalls his mother Lucy telling him that 'Charlie' was stung on the left hand on the palm near the base of the thumb, that he then went blind, lost consciousness and was taken by boat back to Airlie Beach but died before he received medical attention. Dr Ashley Field (Queensland Herbarium, James Cook University, Cairns Campus) provided the following detailed summary from his own recollection of transmitted family knowledge of the fatality. It well demonstrates the ability of a story to survive through oral tradition, and in some respects, in a more complete and accurate form than in many printed sources.

> "My family, the Richardson and Galloway family are from the suburbs of Garbutt and West End, Townsville and knew the parents of Charlie Garbutt who was the young man that died. As I was a shell collector my family told me the story again and again (and again!) as a warning. It varied a bit but in general it goes that the Garbutt family were holidaying on Hayman Island and Charlie was collecting shells at low tide. I think it was in the middle of the year low tides but I don't know for certain, but I was told it happened walking and not diving.
>
> Apparently the cone stung him in the middle of the palm of his hand and he said it was not painful and I don't think anyone panicked much. I was told he returned to and sat on the beach quietly not reporting any pain but soon his lips and face became numb and he started to lose his vision causing the family to panic and seek medical help.
>
> I was told he lost consciousness within an hour and was unresponsive for several hours before dying. I believe that medical help arrived before he died but nothing succeeded in reviving him. I was told the shell was collected and sent to a conchologist at the museum and identified as *Conus geographus* but I was also told the shell was not collected and that it was identified from pictures with some doubt as to its identity. Unfortunately all of my family members who knew Charlie are now deceased and were old when I was told the story.
>
> The legend grew in Townsville and it is often reported that he died within an hour but I am sceptical about that, I think rather he was unconscious within an hour."

Charles Garbutt: careless or just unlucky ?

In 1935 knowledge among the Australian general public of cone snails and how to deal with an envenomation from one of them was essentially non-existent, and even the now standard practice of cardio-pulmonary resuscitation (CPR) was at least 15 years away. As no cone-snail-specific antivenins have to date been developed, modern first aid treatment remains essentially as for snake-bite: (1) application of pressure bandage to the wound area, (2) immobilisation of the affected part (splint), (3) constant monitoring and reassurance of the patient and (4) seeking professional medical help (for further details see Coleman, 1999; Halford *et al*. 2015; Primary Clinical Care Manual (10th ed) 2019). Given that cone snail species differ markedly in their threat to humans, an additional step of photographing the specimen (e.g. via mobile phone) for later identification should be added as it would materially assist those giving medical aid and in most cases help reassure the patient. Below are listed the

principal factors that appear to have contributed to the fatality. Almost any one of these would prove crucial to the events of the 25th of June 1935, but considered in their totality, Garbutt must be viewed as an extremely unfortunate individual rather than careless.

1. The decision to stop to collect shells was made almost at the planned end of the trip, because a suitable low tide was available at Hayman Island Reef and would have good light for reef walking and also fit in with the tour's schedule. If no one had been interested in collecting, or were the tide not low enough or too late in the day, the fatality would not have occurred.

2. The species responsible for his death - *Conus geographus* - just happens to be the most deadly of the approximately 960 currently accepted species of extant Conidae. Although a number of recorded envenomations have been attributed to other species, *C. geographus* is responsible for the vast majority and possibly even all of the known fatalities. In contrast a sting from one of the 30 or so worm eating species known to occur around the Whitsundays would almost certainly not have resulted in a fatality.

3. *C. geographus* only occurs in warmer waters of the Indo-West Pacific, typically in association with coral reefs, and during the day usually hidden in sand under rubble of coral slabs. A holiday almost anywhere else in Australia would have had a different outcome.

4. Despite *C. geographus* having a wide distribution in the Indo-Pacific, it is not a particularly common species anywhere in its range and uncommon on the Great Barrier Reef. Garbutt was both 'lucky' and 'unlucky' to have found a live specimen. Were he to have found an empty shell only, his life would have been spared.

5. The cylindrical shell shape of *C. geographus* is certainly not 'typical' for a cone snail and could be easily mistaken by a novice collector (like Garbutt) for any one of a number of harmless marine snails with similarly wide-aperture shells.

6. The expansive foot of the animal of *C. geographus* is relatively large for a cone snail but not unlike that of harmless volutes (eg *Melo* spp), olives (Olividae), tuns (Tonnidae) or fig snails (Ficidae) In the case of *C. geographus* the animal and particularly the foot is visually appealing, much more so than the shell, and indeed it may have been the site of the beautiful animal crawling that drew him to collect it.

7. The intact periostracum of *C. geographus* exhibits pronounced tufts, which to the untrained eye would appear as some sort of marring overgrowth. It was the urge to scrape off this layer to better reveal the pattern underneath that directly contributed to Garbutt's death (i.e. him placing the live mollusc in the palm of his left hand to remove the layer with a fish scaler).

8. Being a comparatively thin-shelled species, especially in the juvenile and sub-adult stage (like the fatal specimen) *C. geographus* is known to react immediately and aggressively, with defensive stinging, to external pressure on its shell. Garbutt's vigorous handling of the specimen may have triggered a more powerful envenomation than would have been the case through accidental hand-brushing or through sting-penetration of clothing.

9. The seemingly innocuous nature of the initial sting and its primary effect of numbing rather than serious pain appear to have lulled Garbutt into a false sense of security (i.e. the injury appearing to be minor and not worth fussing over, especially among a party of young and presumably very fit men).

10. Garbutt's attempt to show his companions how he had been stung by provoking the animal with a fish hook, while appearing a wreckless act to us today, clearly indicates a lack of knowledge by him or anyone else on board the boat that cone snails are dangerous animals. Other than among experienced marine scientists and well-informed shell collectors, awareness of cone snail biology was not widespread in the Australian community at the time.

11. The fact that when Garbutt began to complain of numbing and eyesight problems he was not initially believed by his shipmates (as we are told in Dr T.B. Clouston's letter to the Queensland Government Analyst). This resulted in the delay (at least an hour) before the situation was deemed critical and the boat began heading

back to the coast for help.

12. Garbutt's predisposition to what appear to be undiagnosed medical problems, as evidenced by his companions' claims that he had exhibited very similar 'turns' on previous occasions. Whatever these problems were, they would surely have contributed in some way to the outcome. Given that the previous 'turns' were accompanied by much the same symptoms as those shown in the fatality, we cannot rule out the possibility that Garbutt had been stung by cones (or something else) on previous trips to the reef.

13. An apparent lack of any available medical expertise either on the launch or at Hayman Island, no doubt compounded by the novelty of the situation for both the skipper and other passengers, directly contributed to the death.

14. The long and unfortunately delayed trip necessary to reach medical help - via boat, lorry, then ambulance (the last stage at night, on a rough, unsealed road) - meant that there was probably nothing that could be done for Garbutt, even if he had reached Proserpine District Hospital alive (five hours after being stung).

Has the death of Charles Garbutt served any enduring purpose ?

Wendy Lewis, in her tourist-enticing book *See Australia and Die* (2007), has remarked that "For all the wrong reasons, Charles became a cause célèbre", dubbing him "the man who shouldn't have picked up a cone shell". While it is true that he remains the only person officially recorded as having been killed by a cone snail in Australian waters, his death remains of great significance and as outlined previously there were many factors beyond his control. The local and national newspaper coverage was substantial and, by today's standards, relatively free from sensationalism. It also focussed public attention on cone snails and the fact that they can be harmful and potentially deadly if handled. Undoubtedly those newspaper reports - which were sometimes lengthy and well-illustrated - helped to save lives by educating readers. No popular books on tropical Australian marine molluscs were available in 1935 and television in this country (as an educational medium) lay 20 years into the future. Even medical doctors and scientists of the day found literature relating to the biology and identification of cone snails not readily available. Hence it was often left to the newspapers to enlighten the general public on many and varied aspects of natural history. The fact that Charles Garbutt was the first and to date only person to die from a cone snail envenomation in Australia can therefore be seen as testament to the educational-effectiveness of the press of the day. Perhaps ironically, the intensive molecular and pharmacological research being conducted at present on cone snail venoms (and their seemingly endless range of complex bioactive peptides) is yielding drugs or drug candidates for relief or management of pain, for muscle relaxation in surgery, for possible diabetes control, for stroke and cardiac issues and several other potential medical or biochemical applications (Layer & McIntosh 2006; Lewis, 2009; Duterte & Lewis, 2013 Olivera *et al*. 2014; 2017). Lastly, concerning the issue of Charles Garbutt's 'fame' raised by Wendy Lewis: he, or at least his case, is frequently cited in research papers on cone snails or conotoxins or in books or magazines on marine shells, and as a result he has arguably achieved more fame than most of his prominent Queensland family.

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APPENDIX 1

Newspaper Articles and Items Consulted (sourced through TROVE search engine of the National Library of Australia and in Queensland Museum scrapbooks)

(i) Garbutt Fatality

Wed 26th June, 1935. Tragic Death. Charles Garbutt. Spike From Shell Enters Hand. (*The Townsville Daily Bulletin*, Qld) (p. 6).

Wed 26th June, 1935. Shell-Fish Sting. Ex-Townsville Resident Succombs. Tragic End to Fishing Party. (*The Northern Miner*, Charters Towers, Qld) (p. 2).

Wed 26th June, 1935. Four Kinds Of Poisonous Shellfish. Found Widely On Coast. Death Of Man In North. (*The Telegraph*, Brisbane, Qld) (p. 6).

Wed 26th June,1935. Death Sting From Shell. Man Succumbs After Great Agony. (*The Courier-Mail*, Brisbane, Qld) (p. 13).

Wed 26th June, 1935. Death by Shellfish. Young Man's Death. (*The Morning Bulletin*, Rockhampton, Qld) (p. 7).

Wed 26th June, 1935. Shell Fish Sting. Man's Tragic Death. End Of Pleasure Cruise. (*The Tweed Daily*, Murwillumbah, NSW) (p. 3).

Wed 26th June, 1935. Deadly Shell. Barbed Tenant Sting Kills. (*The Sun*, Sydney, NSW) (p. 16).

Wed 26th June, 1935. Shell Fish Sting Kills Man. (*The Daily Telegraph*, Sydney, NSW) (p. 1).

Wed 26th June, 1935. Stung by Shellfish. Young Man's Death. (*The Morning Bulletin*, Rockhampton, Qld) (p. 7).

Thur 27th June, 1935. Poisonous Shells Common. Sting Rarely Results in Death. (*The Courier-Mail*, Brisbane, Qld) (p. 18).

Thur 27th June, 1935. Death Sting From Shell. (*The Queenslander*, Brisbane, Qld) (p. 49).

Thur 27th June, 1935. Stung by Shellfish – Young Man Dead. (*The Central Queensland Herald*, Rockhampton, Qld) (p. 30).

Thur 27th June, 1935. Charles Hugh Garbutt Funeral Notices (Funeral Notice – F. Heatley and Sons) (*The Townsville Daily Bulletin*, Qld) (p.6).

Thur 27th June, 1935. [Personal : re life of Charles Garbutt and funeral to occur that day]. (*The Townsville Daily Bulletin*, Qld) (p. 6).

Thur 27th June, 1935. Shellfish Sting Causes Man's Death. (*The Sydney Morning Herald*, NSW) (p.10)

Thur 27th June, 1935. Fatally Stung By Shellfish. (*The Examiner*, Launceston, TAS) (p. 8).

Thur 27th June, 1935. Stung By Shellfish. Young Man's Death. Pleasure Cruise Tragedy. (*The Mercury*, Hobart, TAS) (p. 10).

Thur 27th June, 1935. Death From Sting Of Shellfish. Beautiful Cone Hides Deadly Spike (*The Border Watch*, Mt Gambier, SA) (p. 1).

Thur 27th June, 1935. Stung By Shellfish. Young Man's Death. Cruise To Whit Sunday Islands. (*The Kalgoorlie Miner*, WA) (p. 4).

Sat 29th June, 1935. The Fatal Shell. (*The Townsville Daily Bulletin*, Qld) (p. 7)

Sat 29th June, 1935. [Personal section re funeral of Charles Garbutt]. (*The Townsville Daily Bulletin*, Qld) (p.7).

Mon 1st July, 1935. The Cone Shell. Interesting Facts. (*The Townsville Daily Bulletin*, Qld) (p. 7).

Tue 2nd July, 1935. Stung By Shellfish. Young Man's Death. (*Northern Standard*, Darwin, NT) (p. 4).

Tue 2nd Jul, 1935. Stung by Shellfish. Young Man's Death. Cruise to Whit Sunday Islands. (*The Western Argus*, Kalgoorlie, WA) (p.13).

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Wed 3rd July, 1935. Whitsunday Tragedy. Details of Fateful Incident. (*The Bowen Independent*, Qld) (p.1).

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Fri 5th July, 1935. Deadly Shell. Causes Man's Death. "Plentiful On Reef". (*The Cairns Post*, Qld) (p.8).

Sat 6th July, 1935. Coroner's Court. Inquiry into the Death of Charles Hugh Garbutt. (*The Proserpine Guardian*, Qld) (p.2).

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Sat 3rd Aug, 1935. The Deadly Mollusc. Poisonous Cone Shells. (*The Age*, Melbourne, VIC) (p. 6).

Thur 15th Aug, 1935. Ayr Notes. (*The Townsville Daily Bulletin*, Qld) (p.12). [reports on Coroner's Inquiry 13 Aug 1935].

Tue 20th Aug, 1935. Shellfish Poisoning. Recent Fatality. (*The Daily Mercury*, Mackay, Qld) (p. 13).

27th Aug, 1935. The Deadly Mollusc. Poisonous Cone Shells. Beauty and Value. (*The Daily Mercury*, Mackay, Qld) (p. 10).

Thur 29th Aug, 1935. Deadly Conus Shell. (*The Cairns Post*, Qld) (p.6).

Sat 14th September, 1935. In the Matter of Charles Hugh Garbutt Late of Ayr, Motor Salesman, Deceased (*The Courier Mail*, Brisbane, Qld) (p.1) [announcement re payment of life insurance policy for Charles Hugh Garbutt to his father John Overend Garbutt].

Fri 18th October, 1935 Fatal Shell Fish. Hayman Island Tragedy. Ambulance Investigation. (*The Cairns Post*, Qld) (p.8).

Sat 19th Oct, 1935. Death In The Bite Of Shellfish. Many Instances On Record. Recent Queensland Fatality. (*The Telegraph*, Brisbane, Qld) (p. 8).

Sat 26th October, 1935 Fatal Shell Fish. Hayman Island Tragedy. Ambulance Investigation. (*The Northern Herald*, Cairns, Qld) (p. 42).

Fri 10th September, 1954. Magnificent Shell Collection (*The Longreach Leader*, Qld) (p.3).

(ii) Cruises and Holidays to Whitsundays, The '*Cheerio*'

Sat 17th May, 1930. A Cruise Among the Whitsunday Islands. (*The Bowen Independent*, Qld) (p. 4).

Sat 23rd August, 1930. Out Whitsunday Way Again. (*The Bowen Independent*, Qld) (p. 8).

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Sat 30th July, 1932. Barrier Reef Biological Study. Cumberland and Whitsunday Islands. (*The Daily Mercury*, Mackay, Qld) (p. 9).

Fri 4th November, 1932. Coral Islands Cruise. (*The Western Champion*, Parkes, NSW) (p. 11).

Fri 8th December, 1933. A Whitsunday Trip. (*The Bowen Independent*, Qld) (p. 2).

Tues 12th December, 1933. Hayman Island Expedition. (*The Daily Express*, Grafton, NSW) (p. 7).

Wed 24th January, 1934. The Cheerio's Log. (*The Macleay Chronicle*, Kempsey, NSW) (p. 3).

Thur 29th March, 1934. Holidays at Whitsunday. (*The Bowen Independent*, Qld) (p. 2).

Sat 9th June, 1934. An Island Cruise. (*The Daily Mercury, Mackay*, Qld) (p. 4).

Thur 9th August, 1934. The Beautiful Whitsunday. (*The Daily Mercury*, Mackay, Qld) (p. 8).

Wed 2nd January, 1935. Embury Expedition's Whitsunday Visit. (*The Bowen Independent*, Qld) (p. 2).

Mon 15th April, 1935. The Cheerio. (*The Bowen Independent*, Qld) (p. 2).

Fri 26th Apr, 1935. A Whitsunday Trip. Cruise of the Gwendolyn. (*The Bowen Independent*, Qld) (p. 1).

Sat 22nd August, 1936. A Great Holiday. Three Weeks at the Barrier Reef. (*The Port Macquarie Rivers and Hastings River Advocate*, NSW) (p. 8).

Sat 9th October, 1937. Whitsunday Islands. Mr. Walter Tronson's Impressions. (*The Proserpine Guardian*, Qld) (p. 5).

Thur 17th March, 1938. The Great Barrier Reef. Home of the Living Coral. (*The Western Mail*, Perth, WA) (p. 32).

Sat 30th April, 1938. Launch Cruise. Whitsunday and Cumberland Islands. (The Mackay Daily Mercury, Qld) (p. 13). [advertisement for '*Cheerio*' launch tours operated by Bruce Jamieson].

Mon 2nd May, 1938. Launch Cruise. Whitsunday and Cumberland Islands. (*The Mackay Daily Mercury*, Qld) (p. 11). [advertisement for '*Cheerio*' launch tours operated by Bruce Jamieson].

Thur 20th October, 1938. Tales of the Great Barrier Reef (*The Referee*, Sydney, NSW) (p. 19).

(iii) L.W. Borserini's ambulance service and experience as photographer

Fri 13th July, 1934. Proserpine [news item re monthly meeting of Ambulance Brigade]. (*The Daily Mercury*, Qld) (p.9).

Sat 20th July, 1935. Superintendent's Report. Year Ending 30th June, 1935. (*The Proserpine Guardian,* Qld) (p.4).

Sat 7th September, 1935. Baby and Doll Show [re L. Borserini's photography]. (*The Proserpine Guardian,* Qld) (p. 2).

Sat 23rd November, 1935. First Aid Examinations. (*The Proserpine Guardian,* Qld) (p. 2).

Mon 18th December, 1939. Ambulance Bearer's Move. (*The Cairns Post,* Qld) (p.6).

Fri 29th December, 1939. Ambulance Farewell. Bearer Leaves for Roma. (T*he Johnstone River Advocate and Innisfail News,* Qld) (p.3)

Sat 30th December, 1939. Valedictory. To Ambulance Bearer. Innisfail Function. (*The Northern Herald,* Cairns, Qld) (p. 48.

Fri 28th January, 1949. Toogoolawah Q.A.T.B. attended 142 Cases. (*The Queensland Times,* Ipswich, Qld) (p.5).

APPENDIX 2

Coroner's Report Statements

Coroner's Report on death of Charles Hugh Garbutt – Queensland State Archives ID349592. Inquest No. 521-1935. The following statements are as they appear in the Report including corrections (indicated by strike-trough text).

Witness Statement of Constable David Cruicks McQuaker (given at Proserpine Coroner's Court, 3rd July 1935)

David Cruicks McQuaker sworn states;

I am police constable stationed at Proserpine. I have made inquiries surrounding the death of Charles Hugh Garbutt a single man, aged 27 years who died whilst being conveyed in the Proserpine Ambulance from Cannon Valley to the Proserpine District Hospital on 25th June 1935, and who died as a result of being stung on the palm of the hand by a shell species of the cone species.

I was present at the morgue at the Proserpine District Hospital on morning of 26th June 1935 when a post mortem examination was made on the body of the deceased by Dr T.B. Clouston who subsequently handed me post mortem certificate showing cause of death to be; -

1. Sting from a cone shell fish.
2. Acute Toxaemia
3. Cardiac Failure

As a result of my inquiries I have been unable to discover any suspicious circumstances in connection with the death of the deceased.

Certificate tendered and marked exhibit 1.

[signed by A. McQuaker, and Coroner Morrison]

Witness Statement. Robert Bruce Jamieson, licensed launch proprietor and owner of launch 'Cheerio' (given at Proserpine Coroner's Court, 3rd July 1935)

Robert Bruce Jamieson sworn states; -

I am a licensed launch proprietor and owner of the motor vessel launch "Cheerio". I remember 14/6/35. I was then at Bowen and took over a party and they were to go on a fishing trip round the islands between Bowen and Mackay. I kew the deceased Charles Hugh Garbutt. He was one o the party. I remember 25th June 1935. ~~We were~~ I was on Hayman reef about 12.30 p.m. Later, at about 1.30 deceased and the rest of the party came aboard for lunch. Deceased showed me a shell he had found on the reef and began cleaning the outside with a fish scaler. We then had lunch. After lunch, at about 2.30 p.m. the deceased came to me and showed me the shell and said ~~"This thing has stung me~~ "Bruce, this darn thing has stung me". At the same time he showed me a puncture in the palm of his hand. I advised him to get some nicotine from a pipe smoker and rub it in but he did not get any. He then left me and came back about ten minutes later and he was pricking at the fish inside the shell with a fish hook, forcing it to push out the sting which was a needle like white spike. He then put the shell down and sat down on the wheel house steps and mentioned that his eyes felt funny and a numbness round his mouth. Two men, J. Breen and Bob Gray then took him below deck to the cabin. At this time the boat was travelling round the island and after travelling for some time I pulled in to Hayman Island and dropped the anchor and stopped the engine. I then went below deck and saw deceased supported

between Green [sic] and Gray and he looked so ill that I immediately started the engine, weighed anchor and made for Canon [sic] Valley at full speed arriving there at about six o'clock. I immediately went ashore and found Alex Altmann. One of the party hurried up to phone Dr. and ambulance. Alex Altmann was ready to leave for town and I asked him to take Garbutt in immediately and he did so, Breen and Gray going with him. Garbutt was by this time practically unconscious. Later Mrs. Isbell came to the beach and asked me to come ashore and then she told me that a telephone message had come through that Garbutt was dead when he reached town. I first met deceased about 12 months previously at Hayman Is. I did not see him again until at Bowen on 14/6/35. All the members of the party were a happy crowd and got on well together and ʌ each were on the best of terms with the other and I know of no suspicious circumstances surrounding his death.

[Signed] R. Bruce Jamieson

Witness Statement. Robert Fred Bartlett, Superintendent of Proserpine Centre for the Queensland Ambulance Transport Brigade (given at Ayr Coroner's Court, 4th July, 1935).

Robert Fred Bartlett sworn states; -

I am Superintendent of Proserpine centre of the Q.A.T. Brigade. I remember about 6 p.m. on evening of 25th June 1935. I received an urgent call from Dr. Clouston of Proserpine. He said he had received a message from cannon valley stating that a man had been stung by a fish and was in a serious condition and asking him to bring the ambulance and meet a lorry that was bringing the man in. I went with Dr. Clouston in the Ambulance and met the patient between Proserpine and Cannon Valley. Dr. Clouston examined the patient whom I discovered was Charles Hugh Garbutt. Dr. ordered removal of the patient to the ambulance and instructed me to proceed as quickly as possible to the hospital. When we arrived at hospital Dr. left ambulance car and rushed over to the surgery and while he was away I turned and looked at the patient and noticed his pulse had collapsed and informed the Dr. accordingly. He then examined the patient and pronounced life extinct. I then removed the body to the morgue at the hospital. When I first saw patient he was in an unconscious condition. I have never had occasion to treat any patient for a sting from a shell fish such as stung the deceased. I have never met the deceased ~~whil~~ before and I know of no suspicious circumstances surrounding this case.

[signed] R. F. Bartlett

Witness Statement. Joseph Malachy Breen of Ayr, carrier (given at Ayr Coroner's Court, 13th August, 1935)

Joseph Malachy Breen on oath states,

I am a general carrier, carrying on business in Ayr. On the 13th June, 1935, deceased, nine other men and myself left Ayr and went by train to Bowen, where we joined the Motor Launch "Cheerio" at Bowen, on the morning of the 14th June, 1935, and we toured the islands between Bowen and Mackay. On the morning of the 25th June, we anchored off Hayman Island, and all the members of the party, including the deceased, left the launch and went exploring the reef, returning to the launch for lunch about 1.30pm. We brought back shells that we gathered. Deceased emptied out of a bag shells that he had gathered on the reef, and said to me, "I found a cone shell, I'll show it to you after lunch," We had lunch. Deceased being a small eater, left the luncheon table some minutes before I did and went up on deck and I followed him a few minutes later. Deceased, pointing to the cone shell, said, "This thing stung me", showing me a small puncture in the palm of his left hand. Holding it up he said, "I'll show you what it stung me with", He poked inside the shell with a fish hook, which brought a fine needle like sting to extend out of the shell. Deceased said, "I can feel it in my mouth now, " and he started to rub his mouth with his hand, and a few minutes later he said, "There is something wrong with my eyes, I can hardly see". He sat down at the door of the wheelhouse were [sic] he remained for a few minutes. I went over to

him and he said to him, "How do you feel?" He replied "Not too good. " I said "Come below and I will get you some brandy. " We went below an and I gave him a nip of brandy and he sat down ~~between by himself~~ between Bert John Gray and myself. At this time the motor launch was travelling slowly round Hayman Island, coming to anchor a little later. After the "Cheerio" anchored, Robert Bruce Jamieson, owner of the launch, came the cabin below, and ~~said~~ looked at deceased and said, "We had better make for Cannon Valley". He went on deck and the "Cheerio" got underway and we hurried to Cannon Valley. Arriving there deceased was carried from the launch to a motor truck nearby. Gray and myself accompanied him in the truck to within seven miles of Proserpine where we were met by the Proserpine Ambulance and by Dr. Clouston. After an examination by the doctor, the doctor ~~pronounced life~~ informed that he was a very bad case. Deceased was unconscious and the doctor requested the Ambulance to make with all speed for Proserpine. On arriving at the Hospital Dr Clouston again examined him and he informed me that he had passed away.

I have known the deceased for the past ten years, he was always in the best of health and of a jovial disposition. Up to the time he complained of being stung with the fish, I never ever heard him complain of any illness. Deceased was very popular with all the members of the party and there was no disagreement on the tour.

I am satisfied that there are no suspicious circumstances connected with the death.

[signed] Joseph Breen

Witness Statement. Robert John Gray, farmer (given at Ayr Coroner's Court, 13th August, 1935).

Robert John Gray states,

I am a cane farmer residing at Airdmillan, Ayr. ~~On the 13th June, 1935~~. I knew the deceased, Charles Hugh Garbutt. On the 13th June, 1935, I was one of a party of eleven men who left Ayr by train for Bowen to go on a holiday cruise of the islands between Bowen and Mackay.

We joined the motor launch, "*Cheerio*" at Bowen, on the morning of the 14th June, 1935. Deceased was one of the party. On the morning of the 25th June, we anchored off Hayman Island and all the party went to explore the reef and collect shells. We returned to the launch at 1.30pm for lunch. Deceased came up on deck after lunch and I came up shortly afterwards. I was sitting on the deck and I hard deceased say "I have been stung by a cone shell." He came to me and said, "I'll show you what happened." He picked up the shell in his hand and probed inside with a fish hook, which caused a needle like sting to project out of the shell. Deceased said to me, "The palm of my hand is quite numb where it stung me." Shortly afterwards he complained about a numb feeling round his mouth and he went and sat at the door of the wheel house. Five minutes later I heard Mr Breen offer him a nip of brandy. I went down with them. Deceased drank the brandy and said. "I feel queer, I can hardly see." I noticed that his eyes were glazed. Jamieson came and had a look at him and said, "We had better make straight for Cannon Valley." We hurried for Cannon Valley and got there just after sundown. Deceased was acrried [sic, = carried] to a motor truck and I accompanied him to within seven miles of Proserpine where we met the Proserpine Ambulance and Dr Clouston. He was transferered to the ambulance and they set off for Prosepine Hospital I was told that death had taken place before arrival at the Hospital.

Deceased was very popular with all the party and appeared to be in the best of health till he complained of being stung with the shell fish.

I am satisfied that there is nothing of a suspicious nature connected with his death.

[signed] R.J. Gray

APPENDIX 3.

Other Resources Consulted

Embury Family Papers (1924-1934) OM91-98 John Oxley Library, State Library of Queensland (Box 9267) Four albums of photographs and one box of notes, news clippings (Box 9267, Barcode ENC00000841).

Garbutt/Harvey Albums volumes 1 and 2. Photographs of the Garbutt and Harvey familes from the North Queensland Photographic Collection, Eddie Koiki Mabo Library, James Cook University Library (Townsville, Qld).

Garbutt, R. 2016. *Garbutt Family Footprint* (2016 unpublished history of the Garbutt family) held in the James Cook University Library (Townsville, Qld).

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Tentacle autotomy: an additional mode of asexual reproduction in *Ricordea yuma* (Cnidaria, Anthozoa, Corallimorpharia)

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ABSTRACT

This paper presents a new mode of asexual reproduction of *Ricordea yuma*. Seventeen instances of tentacle autotomy (the deliberate shedding of tentacles) were observed in the tropical corallimorpharian, *Ricordea yuma*, over a four-month period. Of these, seven were deemed to have successfully completed transformation into polyps complete with mouth and tentacles. The majority of tentacles were able to attach to the bottom of the tissue culturing plates they were transplanted into for monitoring. Attachment appeared to have been made via intricate webs made of discharged cnidae, presumed to be spirocysts. Given that tentacle autotomy has been previously reported in both Scleractinia and Actiniaria, this strategy is likely to be used in other corallimorpharian species and may be an important strategy used to quickly clone themselves, monopolize habitats and outcompete other benthic inhabitants.

❑ *clonal, development, replication, polyp, genetically identical*

Corallimorpharians are a distinct group of Anthozoans, superficially described as fleshy and uncalcified solitary polyps similar to sea anemones (order Actiniaria). Morphologically (den Hartog 1980) and genetically (Lin *et al.* 2016) however, corallimorpharians are more closely related to hard corals (Order Scleractinia). There are currently 48 accepted species of corallimorpharians, divided into four families; Corallimorphidae, Discosomidae, Sideractinidae, and Ricordeidae (WoRMS 2022). Corallimorpharians inhabit a broad range of marine habitats, with members adapted to living in both tropical and temperate waters, but also a variety of depths ranging from the shallow intertidal zone down to extremes depths of over 4 km (Fautin 2009; Eash-Loucks 2010).

Corallimorpharians are formidable adversaries of Scleractinia corals and have been shown to not only prevent the recruitment and settlement of coral larvae (Langmead & Chadwick-Furman 1999a) but also smother and kill establish coral colonies in aggressive antagonistic interactions using specialised tentacles and mesentery filaments (Chadwick 1987; Chadwick & Adams 1991; Miles, 1991; Langmead & Chadwick-Furman 1999a, 1999b; Kuguru *et al.* 2004). Despite only being able to travel across benthic surfaces at maximum speeds of 14 mm per month (Chadwick & Adams 1991), corallimorpharians are able to monopolise reef substrate, spatially outcompete hard corals, and cause significant phase shifts in coral assemblages around the world (Muhando *et al.* 2002; Work *et al.* 2008 2018; Carter 2014; Alvin *et al.* 2021). In

addition to the dispersal of planktonic larvae via sexual reproduction (Chadwick-Furman *et al.* 2000), corallimorpharians are also able to reproduce asexually. Some corallimorpharians, such as *Corynactis californica,* have been shown to produce up to 94 genetically identical polyps in a single year (Chadwick & Adams 1991). This prolific rate of replication gives corallimorpharians a competitive advantage on space-limited reefs.

There are five modes of asexual reproduction described within the literature for corallimorpharians. These modes include pedal laceration (den Hartog 1980; Chadwick & Adams 1991), marginal budding (Chadwick-Furman & Spiegel 2000; Lin *et al.* 2013), inverse budding (Chen *et al.* 1995; Chadwick-Furman & Spiegel 2000), longitudinal fission (den Hartog 1980; Chadwick & Adams 1991; Chen *et al.* 1995; Chadwick-Furman & Spiegel 2000) and two-mouth fission (Chen *et al.* 1995).

Each mode of asexual reproduction is primarily centered around the corallimorpharians exceptional regenerative capabilities. As its name suggests, pedal laceration occurs when a portion of the pedal disc, whilst firmly attached to the substrate, is stretched and torn free from the primary polyp (Chia 1976). The resulting lacerated piece then proceeds to regenerate and develop into a new, independent yet genetically identical polyp, complete with a mouth and tentacles (Chia 1976). In marginal budding, portions of the polyps margin, incorporating parts of the body column, pedal, and oral discs, are pinched to form buds which are then detached from the primary polyp, before developing into fully formed secondary polyps (Chadwick-Furman & Spiegel 2000). Similar to that of marginal budding, inverse budding is also achieved through the development of a bud, however, in this mode, a bud is formed when a portion of the pedal disc is raised from the substrate, inverted, and fused together (Chen *et al.* 1995). Over the course of a month, the tissue connecting the bud to the primary polyp constricts and the bud is severed and floats away (Chen *et al.* 1995). Longitudinal fission, which has been reported to occur over the space of a week, involves a polyp quite literally bisecting itself longitudinally through the mouth, exposing internal pharynx and mesentery filaments, to create two separate polyps (Chen *et al.* 1995; Chadwick-Furman & Spiegel 2000). This mode is not to be confused with the slower process of two mouth fission, however, which involves a polyp firstly developing a second mouth and then pinching to cause a divide in the space between the two mouths (Chen *et al.* 1995), or transverse fission (though not reported in Corallimorpharia), where the polyp separates to form two polyps from both the upper and lower parts of the original body (Fautin 2002).

Ricordea yuma is one of two species in the corallimorpharian family Ricordeidae (den Hartog 1980; Fautin 2016; WoRMS 2022). Each species is localised to geographically distinct regions however, with *R. yuma* distributed throughout the Indo-Pacific whilst its counterpart, *R. florida* is situated in the Atlantic Ocean (Torres-Pratts *et al.* 2011; Parr 2019). Both species inhabit shallow tropical waters, ranging from the intertidal zone to depths of 54 m (den Hartog 1980), and are typically found in either colonial aggregations or as solitary polyps (LaJeunesse 2002; Muhando *et al.* 2002; Torres-Pratts *et al.* 2011; Parr 2019). To date, only pedal laceration (den Hartog 1980) and marginal budding (Lin *et al.* 2013) have been observed in Ricordeidae. Here we present strong evidence of a new mode of reproduction in *Ricordea yuma*, which may also be present in other corallimorpharians.

METHODS

In November 2020, mature *Ricordea yuma* polyps (ranging 6 – 10 cm in diameter), from an established population were moved into a 235 L observation tank to monitor for possible spawning. Polyps were originally collected from the Great Barrier Reef locally off the Cairns coast several years prior. The observation tank was kept free of substrate and was connected to a 60,000 L recirculating marine tank system (average temperature 27° C and salinity of 33%), with a flow-through exchange rate of approximately 150 litres per hour.

In January 2021, during normal husbandry checks, a disassociated tentacle, matching the colouration of the *R. yuma* polyps was found on the bottom of the observation tank. There did not appear to be any physical signs of damage or trauma to any of the *R. yuma* polyps. External visual inspections at this time also revealed that polyps no longer appeared to have the well-developed gonads that were previously observed.

Over the course of the next four months, a total of 17 free tentacles were found. Each tentacle, which was negatively buoyant and easily found on the bottom of the observation tank, was gently collected with a pipette and transferred into 5 ml of fresh seawater in a six-well tissue culturing plate for monitoring.

Plates were kept indoors at a constant ambient room temperature of approximately 24 – 25 °C, and exposed to a light intensity of 292 lux (measured with a digital light meter; 0.01-50000 lux range; 5 % accuracy) provided by artificial cool-white, fluorescent lighting on a 12:12 h light/dark cycle. Fifty percent water exchanges were performed on each well twice weekly. Tentacles were monitored over the course of the next five months. All inspections were performed periodically under a dissecting microscope and photographed. Cnidae webs were examined and photographed from below on an inverted microscope so as to not disturb the developing polyps. Unfortunately, the scale at which the cnidae were observed did not allow for thorough cnidae classification to be confidently carried out.

OBSERVATIONS

While all 17 tentacles showed signs of transformation, a total of seven tentacles were deemed to have successfully transformed into polyps, defined here as having a mouth and tentacles. The procession of the transformation into a polyp can be summarised; 1. settlement, and the development of 2. an oral disc, 3. mouth, and finally 4. tentacles (Fig. 1). There was significant variation in the rate of transformation, ranging from 29 to 67 days after collection.

All but one tentacle appeared to successfully attach to the bottom of their well. Of the tentacles that did appear to attach to the bottom of the wells, ten of these were observed to have formed a web of discharged cnidae (Fig. 2). Evidence of these cnidae webs were first observed within 2-19 days after the collection of the tentacles.

Ten of the seventeen polyps died before they had completed the polyp transformation. The causation of death in these polyps remains unknown, as all polyps were treated the same. However, for several of these deceased polyps, it was noted that these tentacles appeared to develop brown abscesses and/or had an algal bloom in their well. The earliest death occurred five days after tentacle detection. Conversely, of these tentacles that did not survive to reach polyp stage, the longest survived for 47 days. Interestingly, this was the sole tentacle that did not attach to the bottom of the plate.

In mid-May, it was noted that surviving polyps were reducing in size. At this time, surviving polyps were between 42 and 89 days post first detection. Attempts were made to relocate polyps (including the tissue culture plates they were attached to) into the main aquarium system, thereby providing them with a constant supply of fresh seawater, natural sunlight, and water temperature (27°C) that has proven favorable for mature polyps. Unfortunately, despite the best efforts to protect the secondary polyps, this relocation was unsuccessful, and all polyps either disappeared or perished within 27 days. Ultimately, the longest surviving polyp, from the first detection to disappearance, was kept for 107 days.

DISCUSSION

The observations presented here of budded tentacles developing into polyps do not fit the descriptions of asexual reproduction that have previously been described for any species within Corallimorpharia. As there were no signs of portions of the pedal or oral disc nor the body column on the fragments, these dissociated tentacles do not align with the descriptions

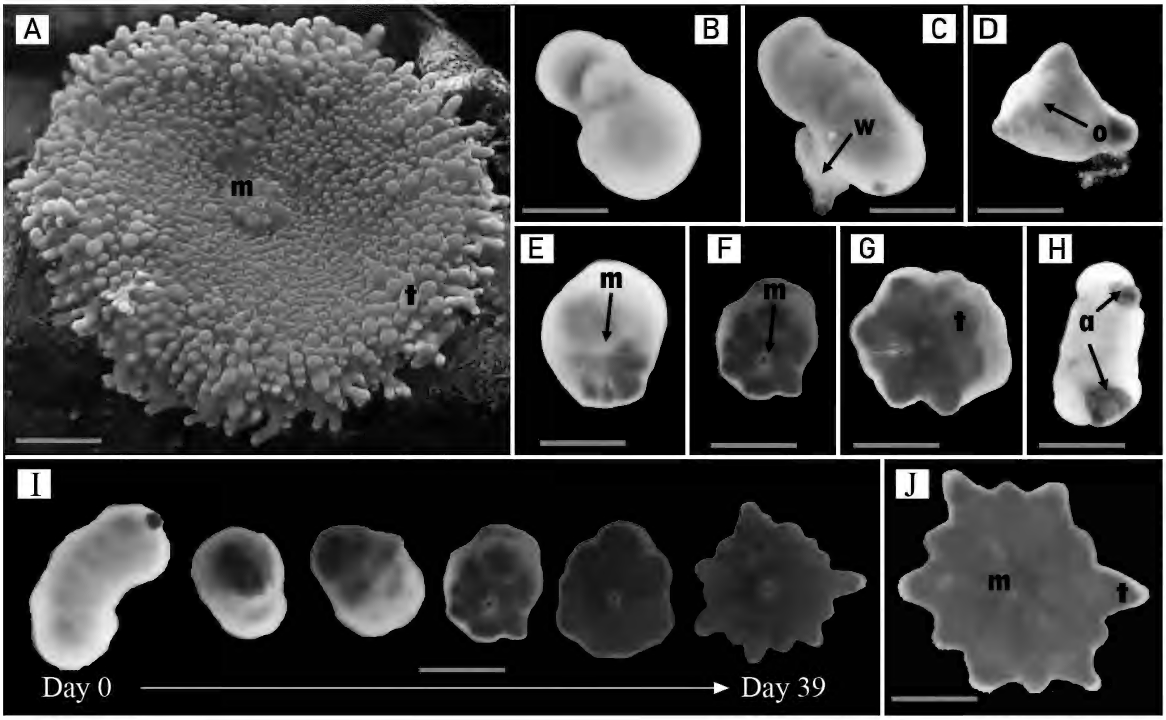

FIG. 1. Growth and developmental stages of *Ricordea yuma* autotomous tentacles. **A**, Adult polyp showing mouth (m) and tentacles (t); **B**, detached tentacle; **C**, tentacle has formed a web (w) of cnidae and has attached the substrate; **D**, flat oral disc (o) has begun to form; **E**, early stages of mouth (m) formation; **F**, mouth (m) is fully developed; **E-G**, tentacles (t) in the initial stages of formation; **H,** abnormal brown abscess (a); **I**, full transition of one autotomous tentacle from first detection (Day 0) to reaching polyp status (Day 39); **J**, a newly formed polyp complete with mouth (m) and tentacles (t). Scale bars approximately: A, 1 cm; B-J, 1 mm; I, transitional timeline not to scale.

provided for pedal laceration or marginal budding in the literature. The observations presented here however do align with a mode of asexual reproduction, tentacle autotomy, that has been previously reported to occur in a range of other orders within Hexacorallia (Scleractiniaria (Toh & Ng 2016) and Actiniaria (Kesava Panikkar 1937; Chia 1976; Cutress 1979; Pearse 2002; Bocharova & Kozevich 2011)), but interestingly also in some Cubozoan (Straehler-Pohl & Jarms 2011) and Scyphozoan (Robinson *et al.* 2019) species. This mode involves the shedding of individual tentacles, via the contraction of a sphincter at the base of the tentacle, from the primary polyp (Kesava Panikkar 1937; Bocharova & Kozevich 2011).

Several theories have been proposed around the occurrence of autotomous tentacles. It has been proposed that tentacle autotomy is a stress response to physical damage, disturbance, or stressful conditions (Chia 1976; Lawn & Ross 1982; Toh & Ng 2016). However, this was mitigated for in this study through predator exclusion. Alternatively, it has also been theorised that asexual reproduction often occurs independently to periods of sexual reproduction (Kesava Panikkar 1937). Our observations support this theory, as the shed tentacles were first seen after polyps no longer showed obvious signs of well-developed gonads.

The webs that were observed in attached tentacles are believed to be the result of cnidae. Cnidae, are specialised organelles used by cnidarians for prey capture, defence, spatial competition, and adhesion (Mariscal 1974). Although the cnidom (specific compliment of

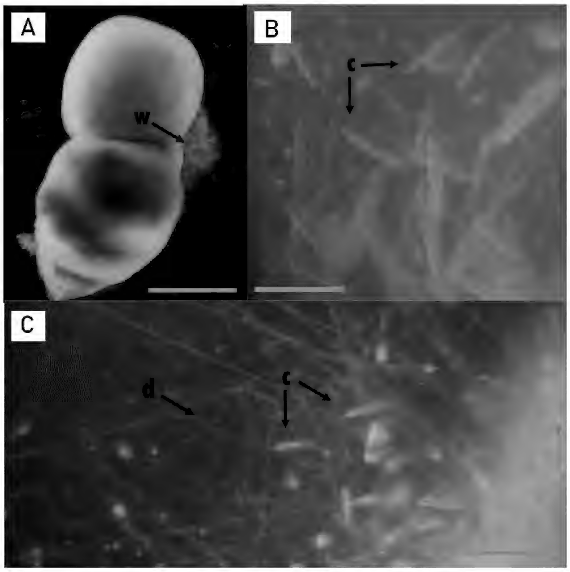

FIG. 2. **A**, autotomous tentacle attached to bottom of the culture plate with a cnidae web (w), viewed from above; **B**, cnidae (c) within the web, viewed from below with an inverted compound microscope; **C**, undischarged (c) and discharged (d) cnidae within the web, viewed from below with an inverted compound microscope. Scale bars approximately: A, 700 µm; B, 80 µm; C, 200 µm

cnidae) of *R. yuma* has not been described, den Hartog (1980) reported that *R. florida*, possessed spirocysts, spirulae (basitrichs), homotrichs (holotrichs), and penicilli (p-mastigophore or p-amastigophore) cnidae types. Given that the fine microfillia on discharged spirocyst threads are known to create an adhesive web-like mesh (Mariscal *et al.* 1977), we conclude that the webs we observed were likely the product of discharged spirocysts located within the epidermal tissue of the tentacles, thus enabling the successful settlement and attachment of budded *R. yuma* tentacles. Future works would seek to examine this cnidae further

Unfortunately, no polyp was successfully maintained longer than 107 days. While the exact reasons for the deaths remain unknown, a combination of the temporary nature of being housed in small volumes of water and also the possibility that there was insufficient lighting and/or temperature within the room, are suspected to be the main drivers behind the mortalities. In future, attempts will be made to mitigate these risks through the use of temperature-controlled water baths, gentle water flow, and designated coral aquaria grow lights. Future work will also involve targeted sampling and characterisation of cnidae within the webs.

In conclusion, the observations presented here are not consistent with the descriptions given for any of the modes of asexual reproduction currently known to occur within Corallimorpharia (den Hartog 1980; Chadwick & Adams 1991; Chen *et al.* 1995; Chadwick-Furman & Spiegel 2000; Lin *et al.* 2013). As they align with details provided for tentacle autotomy seen within Scleractiniaria and Actiniaria (Kesava Panikkar 1937; Chia 1976; Cutress 1979; Pearse 2002; Bocharova & Kozevich 2011; Toh & Ng 2016), we believe that our observations are the first record of this mode of reproduction within Corallimorpharia. Whilst *R. yuma* is the first corallimorpharian to have displayed tentacle autotomy, given that this mode is shared between two other Hexacorallian Orders, it cannot be ruled out that other corallimorpharians may also use this mode of replication. Given the ability of many corallimorpharian species to rapidly monopolise and dominate reef substrate, tentacle autotomy may prove to be an important strategy used by such species to boost their population numbers and instigate inter- and intraspecies aggression with other Anthozoan reef inhabitants.

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Further evidence in support of the recognition of the Freshwater Turtle *Elseya oneiros* (Testudines: Chelidae) from the Nicholson and Gregory rivers of Northern Queensland

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ABSTRACT

Thomson *et al.* (1997) proposed that the extant *Elseya* from the Nicholson-Gregory drainages in northwestern Queensland was conspecific with the holotype of *Elseya lavarackorum,* which comprised a fossil carapace and associated plastron excavated from the late Pleistocene Terrace Site at Riversleigh. Analysis of additional fossil material, and examination of a suite of 16 scute characters (eight for each of the carapace and plastron) by Joseph-Ouni *et al.* (2020) concluded that the two species were distinct and represented separate *Elseya* lineages and proposed the new name *Elseya oneiros* for the extant lineage. Recently, the Turtle Taxonomy Working Group (TTWG) in their 9th edition Checklist of Turtles of the World (TTWG 2021) questioned the status of *E. oneiros* and placed it in the synonymy of *E. lavarackorum,* making the claim, amongst others, that the skeletal characters of Thomson *et al.* (1997) were not addressed. Here we fully address the claims made and evaluate those skeletal characters. We also assess an additional nine thoracic skeletal characters of the pertinent *Elseya* species, including *E. dentata* sensu stricto. The results again do not support the conclusions of Thomson *et al.* (1997) of the holotype of *Elseya lavarackorum* being conspecific with the extant *Elseya* from the Nicholson-Gregory Rivers, reaffirms the proposal offered by Joseph-Ouni *et al.* (2020) for the placement of *E. lavarackorum* in the subgenus *Elseya,* and the status of *E. oneiros* in the Nicholson-Gregory drainages as a distinct species.

❑ *Elseya lavarackorum; Elseya oneiros; Queensland; Australia; skeletal characters; fossils.*

In 1994, White and Archer described a "giant" fossil species of chelid turtle, *Emydura lavarackorum*, on the basis of associated plastron, carapace and pelvic fragments, excavated from the late Pleistocene Terrace Site, Riversleigh, northwestern Queensland. Soon after, in revisiting that taxonomic assignment, Thomson *et al.* (1997) demonstrated its relationship to the genus *Elseya* and assigned the species to that genus. Further, the latter authors concluded that in the absence of any diagnosable difference between the fossil material of *E. lavarackorum* and the living population of *Elseya* snapping turtles in the Nicholson River (then formally undescribed) the two be regarded as a single species. Hence, *Elseya lavarackorum* has been recognised as including both the late Pleistocene and extant populations of *Elseya* of the Nicholson and Gregory rivers region.

Since then, considerable progress has been made in the understanding of morphological characters and interspecies relationships of Australian chelids, especially within the genus *Elseya* (Thomson *et al.* 2015, Thomson and Georges 2016). In 2020, Joseph-Ouni *et al.* proposed an alternative interpretation to that of conspecificity between the living species of *Elseya* in the Nicholson-Gregory drainages and the Riversleigh fossil turtle, utilizing a suite of 16 scutation characters (eight for each of the carapace and plastron) to assess differences between the fossil and extant populations.

Joseph-Ouni *et al.* (2020) concluded that the fossil holotype *E. lavarackorum* (QM F24121) differed markedly from the living population of *Elseya* in the Nicholson-Gregory, sharing only four carapace characters and a single plastron character. By contrast, the fossil holotype of *E. lavarackorum* was found to be more similar in morphology to extant *E. dentata* of the Northern Territory, sharing up to five of the eight carapace characters and up to six of the eight plastron characters. On this basis, Joseph-Ouni *et al.* (2020) concluded that the living population of *Elseya* in the Nicholson-Gregory drainage was different from the fossil holotype of *E. lavarackorum* and represented an undescribed species. This new species was recognised as having its closest affinities with other extant Queensland *Elseya* species assigned to the subgenus *Pelocomastes* by Thomson *et al.* (2015), and therefore, Joseph-Ouni *et al.* (2020) described it as *Elseya* (*Pelocomastes*) *oneiros*. By virtue of its closer affinities to *Elseya* (*Elseya*) *dentata* s.s., the fossil holotype of *E. lavarackorum* was regarded as belonging to the subgenus *Elseya*.

In addition to the fossil holotype of *E. lavarackorum*, two other fossil specimens from Riversleigh, QM F30817, and QM F30818, were examined by Joseph-Ouni *et al.* (2020) and by Thomson *et al.* (2015). Both are partial plastrons excavated contemporaneously with the holotype of *E. lavarackorum* from the same stratum at the Terrace Site, but not mentioned in the description of that species. Specimen QM F30817 had at least five of the plastron characters (out of the six that were able to be evaluated) in common with the holotype and was regarded as conspecific with *E. lavarackorum*. However, QM F30818 had only two characters (out of the eight that could be evaluated) in common with the holotype of *E. lavarackorum* and seven characters of the eight in common with *E. oneiros*, strongly suggesting it was synonymous with that species. As such, it appears two sympatric species of *Elseya* were present at Riversleigh in the late Pleistocene, one represented by two fossils (QM F24121 and QM F30817), that we regard as *E. lavarackorum* s.s., and one represented by a single fossil (QM F30818) considered conspecific with the extant populations in the Nicholson-Gregory drainages described as *E. oneiros*.

Recently, the Turtle Taxonomy Working Group (TTWG) in their 9th edition Checklist of Turtles of the World (TTWG 2021) questioned the status of *E. oneiros* and placed it into the synonymy of *E. lavarackorum*. In doing so, the TTWG made several claims in Annotation 30 of their checklist. We find the rationale for the synonymy presented by the TTWG was not well-founded and contained errors of fact. We present the claims made by the TTWG below in italic text in order of appearance (bold text is ours for emphasis), along with our responses. Their citations of Joseph-Ouni *et al.* (2021) refers to Joseph-Ouni *et al.* (2020).

> TTWG: That '*Joseph-Ouni et al. (2021) described apparent shell scutation differences between two late Pleistocene fossils (one partial carapace and one plastron) of E. lavarackorum from the Riversleigh site* ***and several living specimens of E. lavarackorum*** *from the Nicholson and Gregory River drainages, and concluded that the living specimens were not the same species as the fossils, in contradiction to the earlier conclusion by Thomson et al. (1997) that the fossil and living specimens belong to the same species.*'

The statement by the TTWG is incorrect in that it does not take into account the extent of all of the material examined by Joseph-Ouni *et al.* (2020) in describing *Elseya oneiros.* Reference to Appendix B 'Specimens Examined and Character Scoring' of that publication clearly identifies six museum specimens, one fossil specimen, and four live specimens of *Elseya oneiros* that were scored for comparison with the fossil holotype of *Elseya lavarackorum* and lists an additional eight museum and living specimens under 'Additional Specimens Examined' and an extensive array of comparative material of other *Elseya* species. The museum specimens are held by public institutions and are available for scrutiny.

> TTWG: That '*Thomson et al. (1997) had based their conclusions of* ***conspecificity*** *on* ***several*** *skeletal characters and* ***a single scutellation character*** *that demonstrated a close relationship between the fossil and living specimens, yet Joseph-Ouni et al. (2021) did not address or describe any of the skeletal characters, focusing instead on a variety of other apparently variable scutellation differences.*'

While TTWG did not specify which osteological and scutellation characters were used by Thomson *et al.* (1997) for this purpose, the paper by Thomson *et al.* only provided character state scores for five characters (identified by them as A-E), of which the first three were osteological and the remainder scutellation. Of these, the condition for two (characters A & C) was shared broadly across all the species of *Elseya* and *Emydura* (using the current concept of *Elseya*, excluding the species in the *latisternum* complex subsequently transferred to *Wollumbinia*). The condition for character D was shared across all *Elseya* species examined, and character E showed a difference only in one species, *Elseya novaeguineae,* making all four uninformative in inferring relationships of *lavarackorum*, or conspecificity of the *lavarackorum* holotype with the extant species. Only a single skeletal character (Character B) in that study, pertaining to the anterior bridge suture shape, was shared between the holotype of *E. lavarackorum* and the living species from the Nicholson and Gregory River drainages to the exclusion of species in the *Elseya dentata* group s.s. and *E. novaeguineae.* This character was also shared with two other species of *Elseya* in Queensland not formally described at that time (since described as *E. albagula* Thomson *et al.* 2006 and as *E. irwini* Cann 1997 / *E. stirlingi* Wells 2007). Thomson *et al.* (1997) also stated that the holotype of *E. lavarackorum* and the extant species from the Nicholson and Gregory River drainages were indistinguishable in the indentation of the anterior margin of the carapace, but that this feature was also 'variable among the Queensland forms of *Elseya dentata.*' As such, and by default, the three extant Queensland *Elseya* species (presumably those listed under *E. lavarackorum* (Nicholson – Gregory), *E.* sp. aff. *dentata* (Johnstone) = *E. irwini* / *E. stirlingi*, and *E.* sp. aff. *dentata* (Burnett) = *E. albagula*) were equally indistinguishable from the fossil holotype of *E. lavarackorum* on the basis of shared character states across the three skeletal characters and two scutellation characters scored in the data matrix by Thomson *et al.* (1997). However, it should be noted that Thomson and coauthors subsequently recognised two of these taxa as distinct from the fossil holotype of *E. lavarackorum* in describing one (*E.* sp. aff. *dentata* (Burnett) as *E. albagula* Thomson *et al.* 2006 and treating another (*E.* sp. aff. *dentata* (Johnstone) as the species *E. irwini* (Georges & Thomson 2010).

In reality, the evidence presented by Thomson *et al.* (1997) for conspecificity of the

holotype of *E. lavarackorum* and the living species of the Nicholson and Gregory Rivers, to the exclusion of all other *Elseya* species, rests on one plastron scutellation character, the 'sigmoidal shape of the sulcus between the humerals and pectorals on the plastron'. This character state was examined by Joseph-Ouni *et al.* (2020) and identified as representing two separate conditions (see Character 4 of Joseph-Ouni *et al.*, 2020 – their plate 5a). In the first condition, found in the fossil holotype of *E. lavarackorum,* the humeral-pectoral sulcus could be interpreted as 'sigmoidal' (approximating an S-shaped) with its lateral extremity (on the edge of the plastron) and its medial extremity (at its intersection with the midline sulcus) on the same anterior-posterior level or plane. In extant *Elseya oneiros*, the humeral-pectoral sulcus is not sigmoidal, rather its lateral extremity (on the edge of the plastron) has a more anterior position to its medial extremity (at its intersection with the midline sulcus) i.e. in a different plane. These conditions represent characters 3 and 4 in Joseph-Ouni *et al.* (2020) and were shown to be consistent across the specimens of the extant species assigned to *Elseya oneiros*, and clearly diagnostic with regard to the holotype of *E. lavarackorum*, and to other species in the subgenus *Pelocomastes*.

While the details of the plastron that characterise and separate *Elseya oneiros* and the holotype of *E. lavarackorum* were qualitatively examined and illustrated in Joseph-Ouni *et al.* (2020), we here offer a quantitative assessment of plastral sulcus ratios (Figure 1) as further evidence for their recognition as two distinct species.

> TTWG: That '*basing these variable differences on only single carapacial and plastral fossil specimens* ***without regard to the extent of variation in living specimens*** *does not, in our opinion, constitute adequate demonstration of significant enough specific differences to warrant recognition of separate taxa, and as such most of us consider E. oneiros to be a junior synonym of E. lavarackorum.*'

Again, this statement by the TTWG misrepresents both the variation documented and the extent of material of the extant species from the Nicholson and Gregory River drainages examined by Joseph-Ouni *et al.* (2020) in describing *Elseya oneiros*. The effort of these authors in that regard has been addressed above.

> TTWG: That '*Joseph-Ouni et al. (2021) erroneously placed E. lavarackorum in the subgenus Elseya, despite the clear allocation of that species to the subgenus Pelocomastes, as demonstrated by its skeletal morphology (Thomson et al. 1997, 2015).*'

The placement of *E. lavarackorum* by Thomson *et al.* (1997) within the 'Queensland *Elseya* group' (subgenus *Pelocomastes*) vs the *Elseya dentata* group (subgenus *Elseya*) rests on a single character difference (Character B of Thomson *et al.* 1997: – Table 1) pertaining to the shape of the axillary bridge suture with the carapace, given that the states for all other characters (four of five) in the data matrix are also present in the *Elseya dentata* group. While this single character state was not discussed by Joseph-Ouni *et al.* (2020), the reallocation of the holotype of *E. lavarackorum* to the subgenus *Elseya* was intentional (not mistakenly as implied by TTWG) and was based on the extent of concordance of five of the eight carapace characters and up to six of the eight plastron characters they investigated (and fossil specimen QM F30817 in five of six plastral characters able to be scored).

We note also that Thomson *et al.* (2015) offered no further evidence in terms of character states applicable to the fossil holotype of *E. lavarackorum* in support of their formal placement of it within the subgenus *Pelocomastes*, to the exclusion of the subgenus *Elseya* (see also Joseph-Ouni *et al.* 2022, in press for a full review of the lectotype of *Pelocomastes* and the type species' character states and nomenclature).

The TTWG criticism of the character states and variability comes down to a few sweeping statements. They did not specify which character states they considered to be so variable as to dismiss all other characters evaluated from further consideration, nor did they provide or give reference to any conclusive contrary

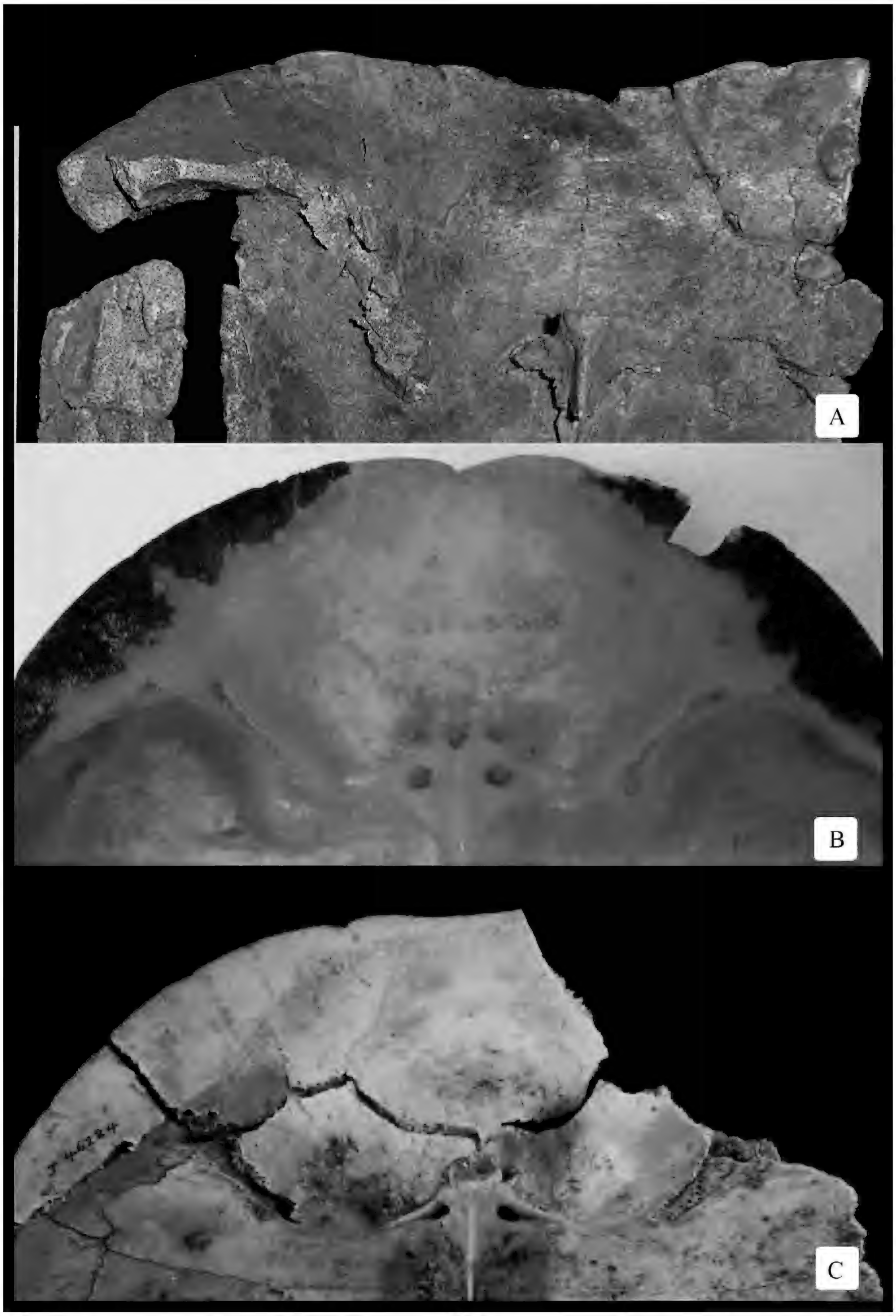

PLATE 1. Comparison of the anterior ventral carapace surfaces of **A**) holotype of *Elseya lavarackorum* (QM F24121); **B**) *E. dentata* (QM J59277, Daly River, Northern Territory); **C**) *E. oneiros* (QM J46284, Nicholson River, Qld.). See Plate 2 for explanatory differences.

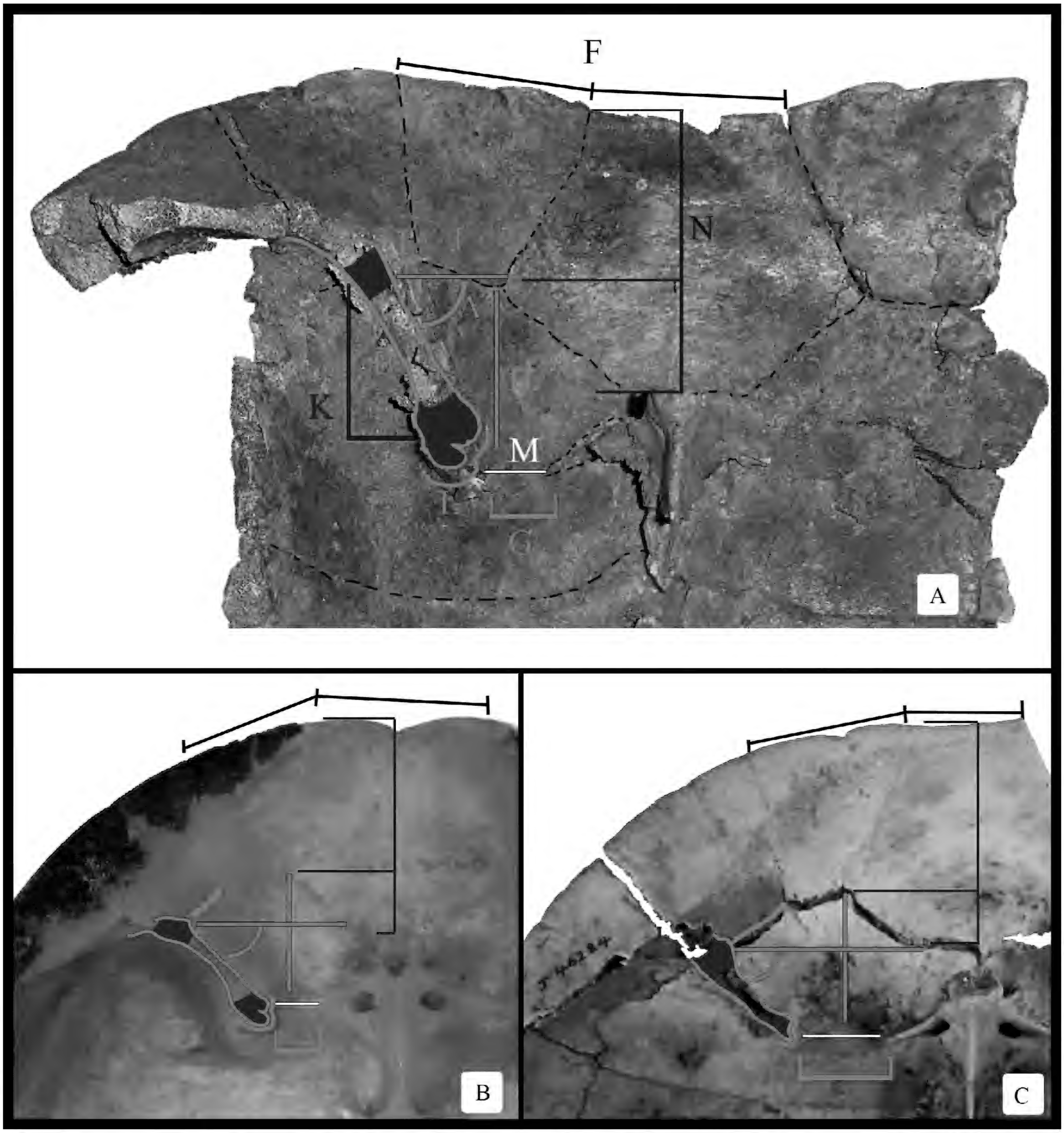

PLATE 2. Above: Visual guide to skeletal characters A, B in Thomson *et al.* (1997) and F - N, added in this current study, demonstrated on the internal anterior carapace of **A**) the holotype of *Elseya lavarackorum* (QMF24121). Same characters on that of **B**) *E. dentata* (QM J 59277 - below left) and **C**) *E. oneiros* (QM J46284, below right). See text for definitions of characters and comparative descriptions.

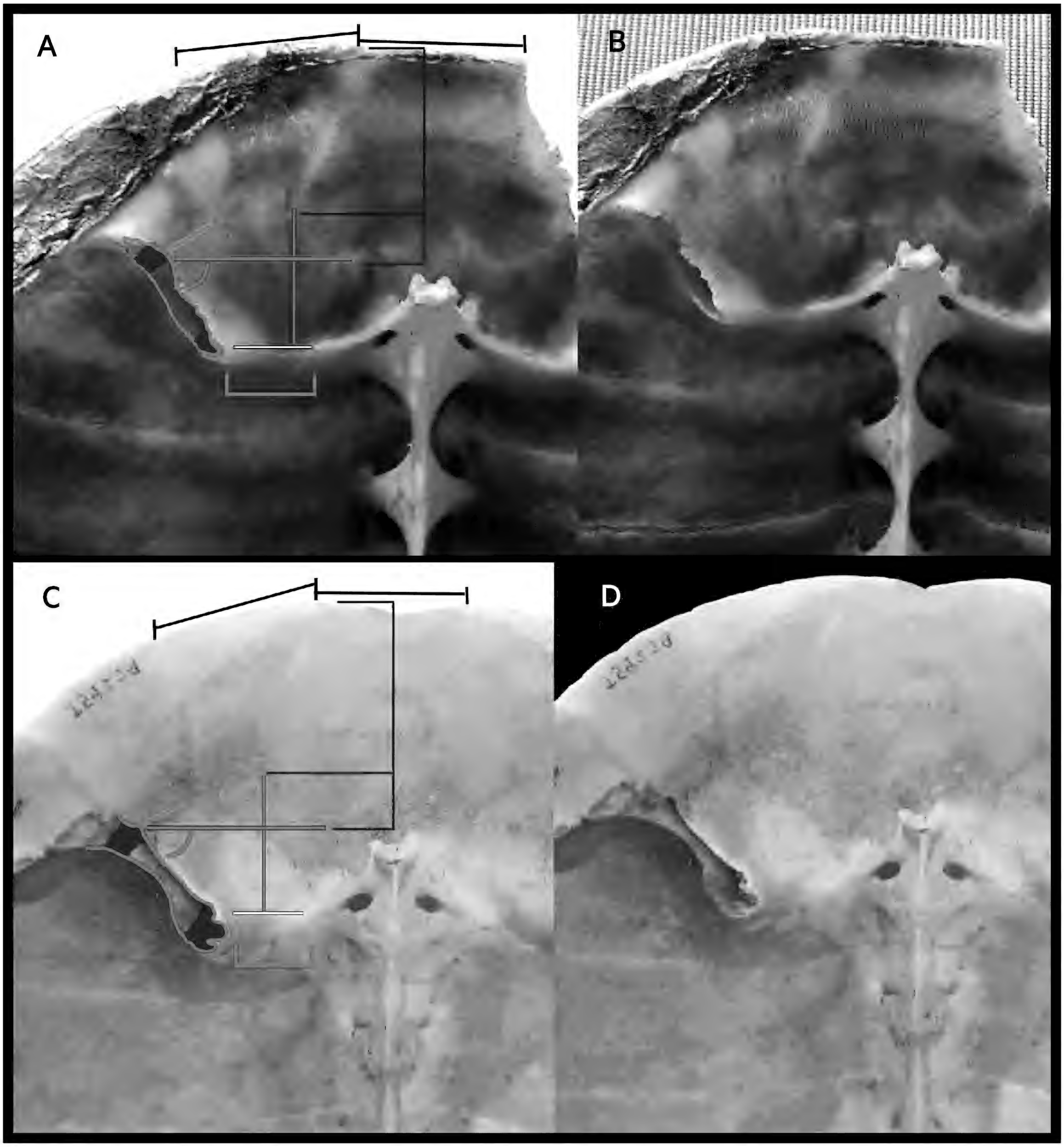

PLATE 3. Interior (visceral) views of the anterior carapaces: a second specimen of *E. oneiros,* **A**) Gregory River, JC collection, (image of actual specimen is mirror-reversed for ease of comparison) and a second specimen of *E. dentata;* **B**) - Douglas River, QM J59279, (image of actual specimen is mirror-reversed for ease of comparison and suture clarity), both with the labelling of the same characters in Plate 2.

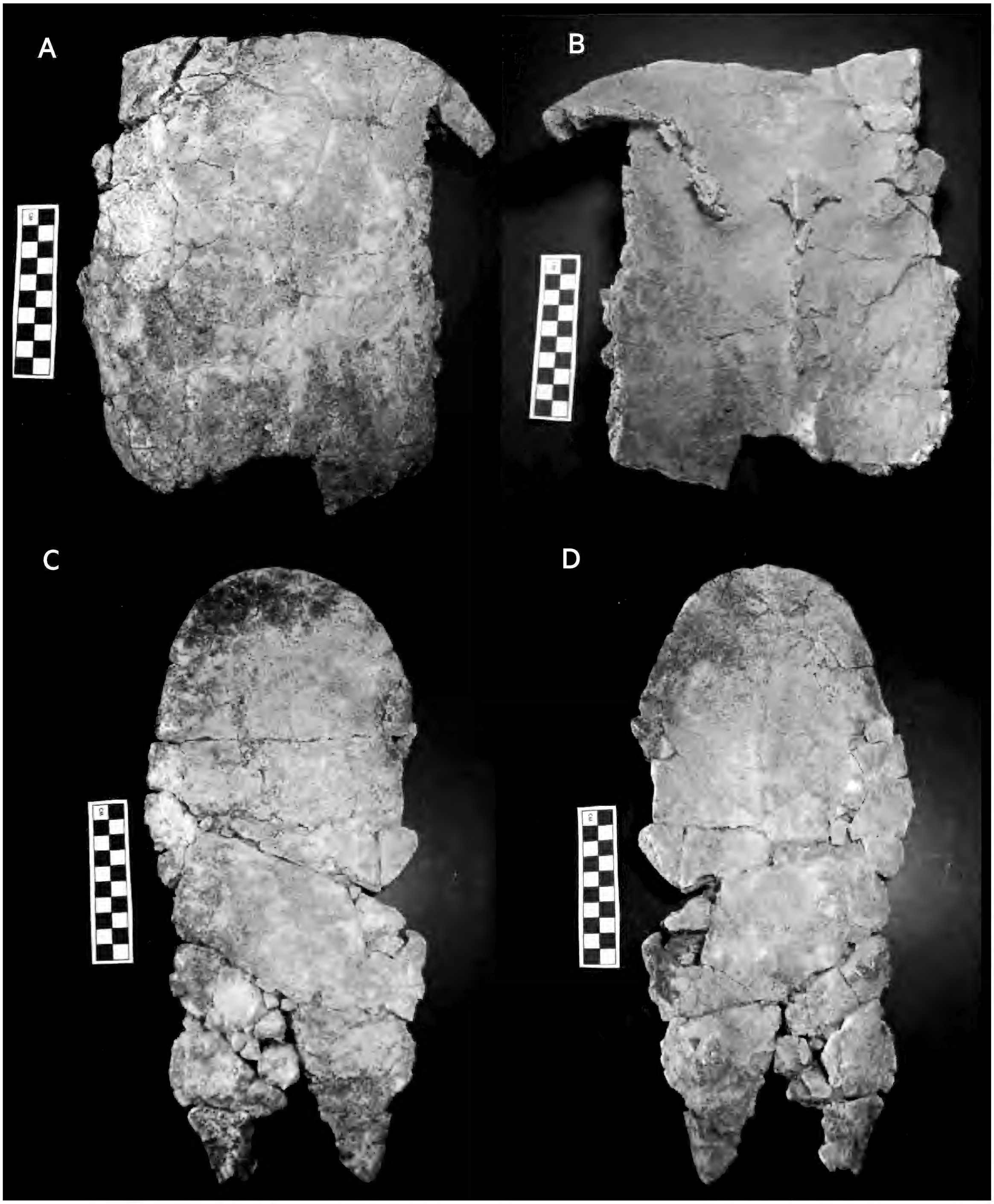

PLATE 4. New images of the holotype of *Elseya (Elseya) lavarackorum* QM F24121, **A**) in its current state, in external and, **B**) internal carapace; (**C-D**) and plastron. The medially constricted axillary buttress suture scar and 'bulb' terminus are easily discernible (B).

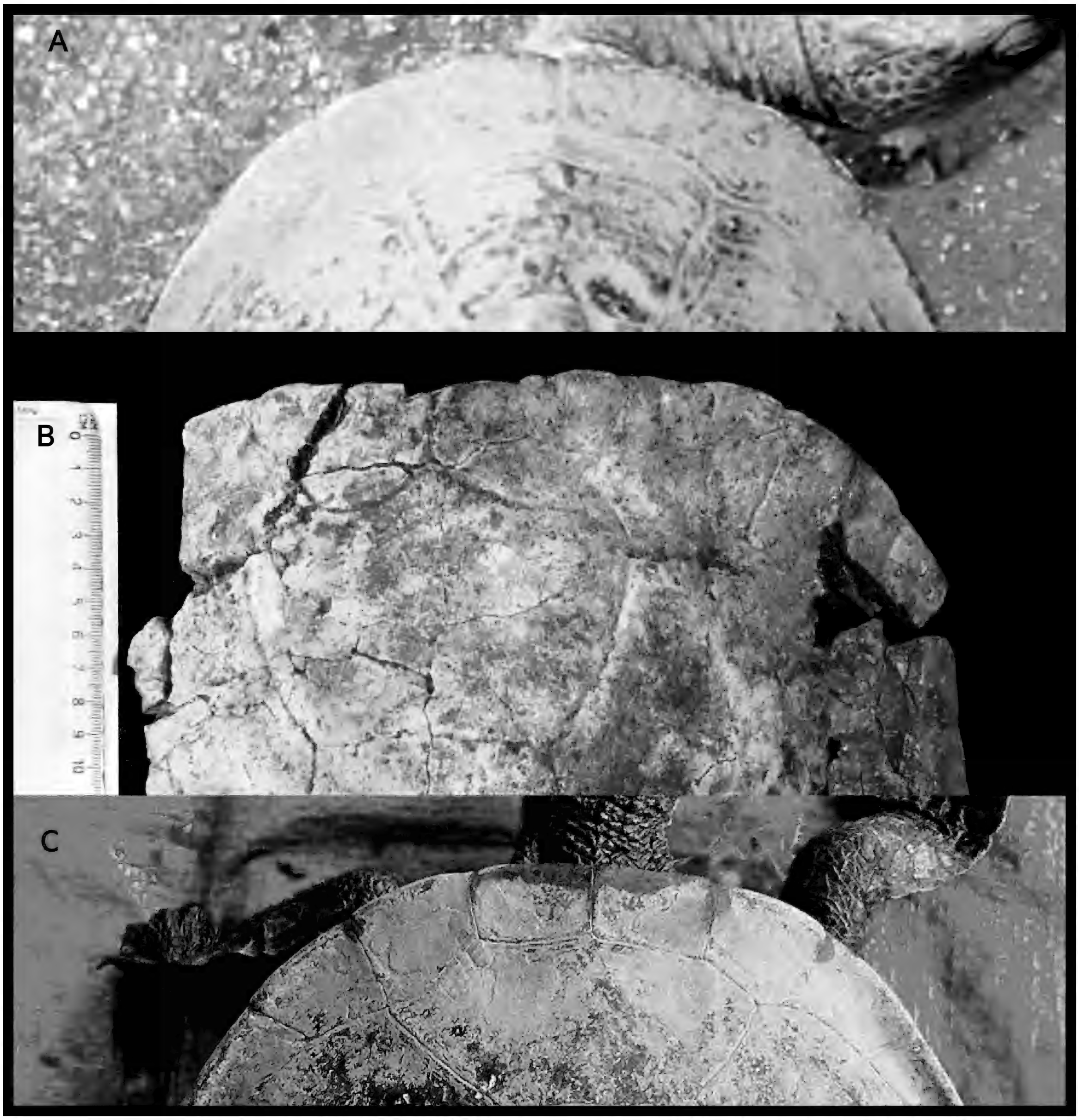

PLATE 5. (A-C) Comparison of the scute sulci, anterior carapace and nuchal emargination of: **B**) holotype of *Elseya lavarackorum* (QMF24121) with, **A**) a live *E. dentata* from Katherine River, Northern Territory and, **C**) a live *E. oneiros* from Gregory River.

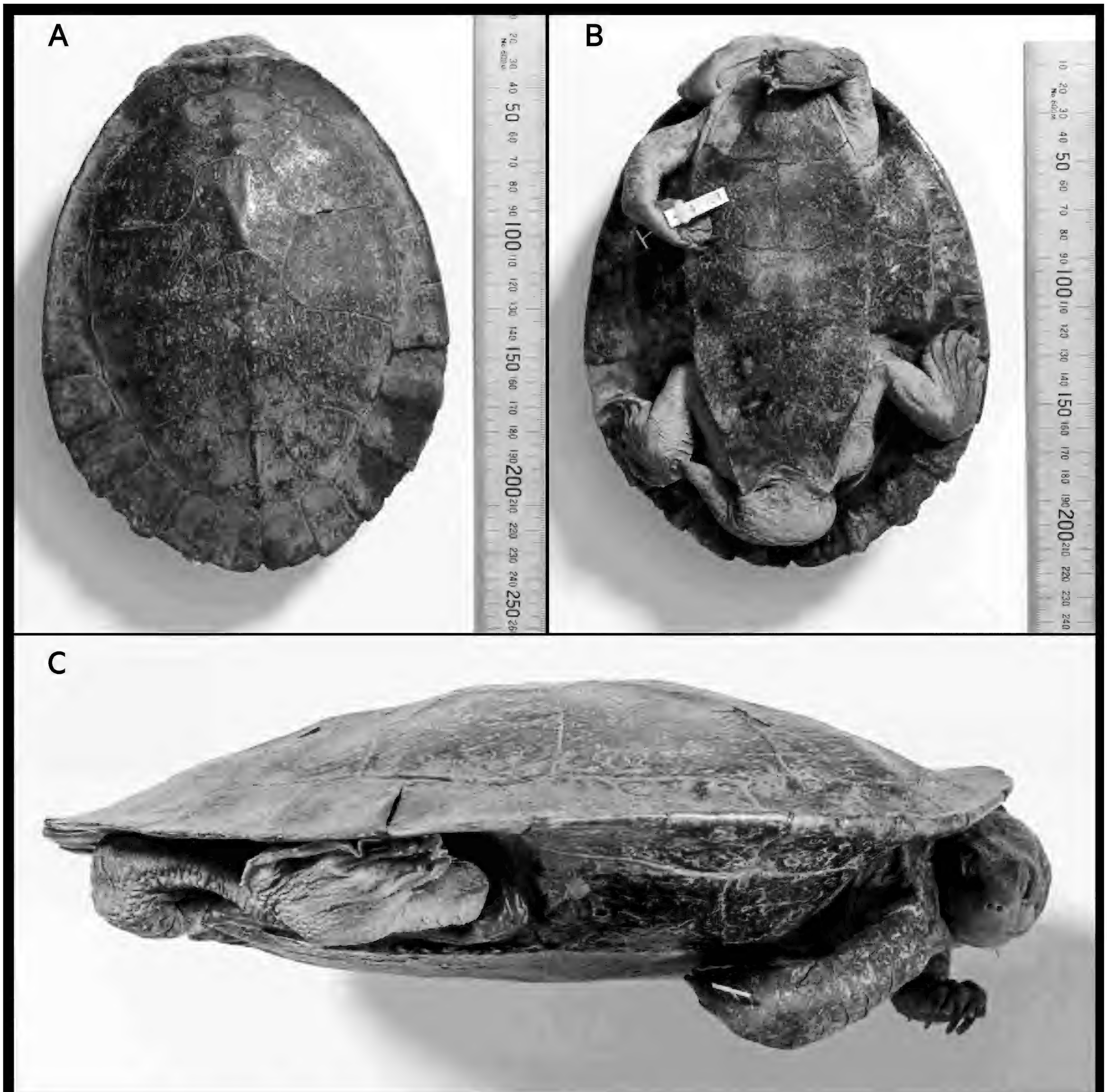

PLATE 6. Holotype of *Elseya oneiros* QMJ 47908 in dorsal **A**), ventral; **B**) and lateral views; **C**), and view of the gular-intergular scutes with repositioning of the left forelimb; **D**). All images © Queensland Museum, Peter Waddington.

evidence for such alleged variability. Contrary to the assertions made by TTWG, variation in these characters was covered by Joseph-Ouni *et al.* (2020) and was based on multiple specimens of all described and known undescribed species of *Elseya*, and the additional fossil specimens. On these points future researchers will have to come to their own conclusions after impartial consultation of the publications and referenced material.

Regarding the criticism by the TTWG that Joseph-Ouni *et al.* (2020) did not consider the skeletal morphology of Thomson *et al.* (1997, 2015) we contend that the analysis of skeletal morphology as presented by Thomson *et al.* (1997) identified (erroneously) no differences between the fossil holotype of *E. lavarackorum* and the 'Queensland *Elseya* group' which included *E. oneiros, E. stirlingi/irwini* and *E. albagula*. The carapace and plastron characters examined by us in 2020 identified diagnosable differences.

We take the opportunity here to rectify our omission identified by the TTWG with regard to assessing the skeletal morphology of the fossil holotype of *E. lavarackorum* and *E. oneiros*.

SKELETAL AND SCUTELLATION CHARACTERS ASSESSED

We have reviewed the three thoracic skeletal characters, A to C, and the two scutellation characters, D and E, reported by Thomson *et al.* (1997), and here present a further nine skeletal characters evaluated by us in assessing differences among the three key taxa under discussion: *E. oneiros, E. dentata* and the holotype of *E. lavarackorum*. These characters are here labelled Character F to N for continuity of presentation with the characters identified by Thomson *et al.* (1997).

Examination of relevant internal skeletal characters of extant taxa was reliant on disarticulated shells. For *E. oneiros* we have examined the same specimen (QM J46284 – Plate 1, 2) used by Thomson *et al.* (1997 – Fig 2E, 2F), and an additional skeletal carapace (JC collection – Plate 3) to ascertain the condition of bony characters in that species. For *E. dentata* s.s. we have examined the same specimen (QM J59277 from the Daly River, Northern Territory – Plate 1, 2) as used by Thomson *et al.* (1997: – Fig 2C, 2D), and a second specimen (QM J59279, from the Douglas River, Northern Territory - Plate 3) to account for variation in that species.

It is important to note that until the current paper, assessment of the visceral osteological characters applicable to the extant species *E. oneiros* via disarticulated shells was limited to a single specimen in the Queensland Museum (QM J46284) for both Thomson *et al.* (1997) and Joseph-Ouni *et al.* (2020). The specimens listed by Thomson *et al.* (1997) in the Queensland Museum from the Nicholson-Gregory rivers are either articulated shells or 'whole' animals (additional juvenile specimens were figured in Plate 12d in Joseph-Ouni *et al.* (2020).

Terminology. Regarding the terminology used for carapace bones, Thomson *et al.* (1997) state in their 'Materials and Methods' that "Throughout this paper, names of the bony elements of the shell and the overlying scutes follow those of Zangerl (1969)'. However, they use the term 'pleural' for carapace bones, in contrast to Zangerl (1969), who described these as 'costals' and used 'pleural' for carapace scutes that overlie them. Here, we have followed Zangerl (1969).

Thoracic Skeletal Characters. To avoid ambiguity, we present the thoracic skeletal characters used by Thomson *et al.* (1997) verbatim, noting that their '*gomophosisis*' is correctly spelled '*gomphosis*'.

> ANTERIOR BRIDGE STRUTS Character A Contact with Pleural I
>
> A0. In the primitive state, the posterior edge of the bridge-carapace suture runs parallel and adjacent to the rib/gomophosisis of pleural 1 (Fig. 1A-F).
>
> A1. In the derived state, the posterior edge of this suture contacts the rib/gomophosis is at its anterior end, but is set at a forward divergent angle of between 15 and 50°. This

angle is most pronounced in *Emydura*, least in *Rheodytes* (Figs. 2A-F, 3A-D).

Character B. Bridge suture shape.

Bl. The anterior and posterior edges of the bridge-carapace suture diverge from their point of congruence closest to the vertebral column. The widest extent of the suture is distal to the vertebral column and there is no medial constriction (Fig. 1A-F).

B2. The anterior and posterior edges of the bridge-carapace suture are parallel or closely so with a prominent suture surface between them. There is no medial constriction (Figs 2A-B, E-F, 3A-B).

B3. The bridge-carapace suture is expanded for its full length, but more so at extremes, there being an obvious medial constriction (Fig. 2B).

B4. The bridge-carapace suture narrows from its widest point proximal to the vertebral column and constricts completely to form a ridge confluent with the edge formed by the ventral suture of the peripheral bones (Fig. 3C-D).

RIB/GOMOPHOSISIS OF PLEURAL 1.
Character C. Rotation of the Rib/Gomophosisis.

C0. The ventral surface of the distal extent of the rib/gomophosisis is rotated obliquely, to face ventrally but with posterior inflection (Figs 1A-F, 2A-B).

C1. The rib/gomophosisis shows no such torsion distally (Figs 2C-F, 3A-D).

Characters A and B relate to morphology of the suture between the bridge strut, or buttress process of the hyoplastron with the thoracic surface of costal 1. This character is most clearly observed from morphology of the sutural scar on the thoracic surface of the carapace. In the holotype of *E. lavarackorum* broken remnants of the hyoplastron axillary buttress remain attached to the carapace, but the shape and configuration of the suture between these elements is readily seen.

For Character A the anterior edge of the bridge-carapace suture is set at a forward divergent angle to the rib/gomphosis of costal 1. The derived state (A1) cited by Thomson *et al.* (1997), occurs in *E. oneiros, E. dentata,* and the holotype of *E. lavarackorum*. However, the angle of the anterior edge of the bridge suture relative to the rib/gomphosis in the fossil holotype of *E. lavarackorum* is at an angle of 60-70° (character A1 of Thomson *et al.* 1997), i.e. close to parallel with the longitudinal axis of the animal. In *E. dentata* and *E. oneiros* the anterior edge of the bridge suture is oblique to the rib/gomphosis at an angle of 45-50°. In support of our reassessment of this character we illustrate the state of the anterior bridge suture scar (Plates 1 & 2) in the *E. lavarackorum* holotype, *E. oneiros* and *E. dentata* for Character A of Thomson *et al.* (1997).

Our assessment of Character B, the shape of the axillary bridge suture and degree of medial constriction of the suture in the fossil *E. lavarackorum* holotype is not in agreement with that of Thomson *et al.* (1997). From our examination of the thoracic surface of the carapace the correct state for this character in the holotype of *E. lavarackorum* is a medial constriction of the bridge-carapace sutures (character state B3 of Thomson *et al.* 1997), not parallel or closely so (character state B2) as presented by Thomson *et al.* (1997). As such, the condition found in the holotype of *E. lavarackorum* is in agreement with that found in the *Elseya dentata* group s.s. and not the 'Queensland *Elseya* group' (now the subgenus *Pelocomastes*), of which *E. oneiros* is a member. As evidence of our reassessment of this character we illustrate the state of the anterior bridge suture scar (Plate 1, 2) in the holotype of *E. lavarackorum*, and specimens of *E. oneiros* and *E. dentata* for Character B of Thomson *et al.* (1997), and again in Plate 4 (upper right) in which this constriction can be clearly observed in new images we provide of the holotype of *E. lavarackorum*.

Character C, which assesses the extent to which the ventral surface of the distal extent of the rib/gomphosis is rotated obliquely, to face ventrally but with posterior inflection, is regarded as the

same in the holotype of *E. lavarackorum*, *E. oneiros* and *E. dentata*, in agreement with Thomson *et al.* (1997).

The two scute characters assessed by Thomson *et al.* (1997), and labelled characters D (Relative width of Vertebral 1) and E (Cervical Scute) were both addressed in Joseph-Ouni *et al.* (2020), and need not be discussed further as there was agreement with the determination of the state presented by Thomson *et al.* (1997), and they provide no differentiation between the fossil holotype of *E. lavarackorum* and extant *E. oneiros* or *E. dentata* s.s.

Hence, the entirety of the case for conspecificity of the holotype of *E. lavarackorum* with that of the extant Nicholson-Gregory *Elseya* species (*E. oneiros*) presented by Thomson *et al.* (1997) rests on the characterization of a single scute character (qualitatively described by Thomson *et al.* 1997 in the text, that being the nature of the sinuosity of the humeral-pectoral sulcus) and a single skeletal character (Character B). The scute character was shown to have been incorrectly assessed (Joseph-Ouni *et al.* 2020), and the skeletal character is shown here to have been incorrectly assessed.

Further, reliance on the five skeletal and scutellation character states presented by Thomson *et al.* (1997) as the basis of conspecificity between the holotype of *E. lavarackorum* with the extant Nicholson-Gregory *Elseya* species would equally place *E. albagula* and *E. irwini* / *stirlingi* (sensu Georges & Thomson 2010 for Johnstone River, Queensland population) into the synonymy of *E. lavarackorum*.

The additional nine skeletal characters are presented here (Plates 2, 3) for the fossil holotype of *E. lavarackorum* and specimens of extant *E. oneiros* and *E. dentata* s.s., and we evaluate their condition in assessing differentiation between these three taxa. These characters, labelled Characters F to N for continuity of presentation with the characters utilised and labelled by Thomson *et al.* (1997), are initially described, and the various states observed listed. Note – 'ABSS' = Axillary bridge suture scar.

Character F - Nuchal-Peripheral 1: Relationship of the length of the anterior border of the nuchal bone in relation to that of the 1st peripheral bone, measured straight. This occurs in three typical conditions:

F0. Anterior edge of nuchal wider than anterior edge of peripheral 1 (some *dentata*).

F1. Anterior edge of nuchal not as wide as anterior edge of peripheral 1 (some *oneiros*).

F2. Anterior edge of nuchal and anterior edge of peripheral 1 subequal in width (some *dentata*, some *oneiros*, *lavarackorum*).

Character G – Proximity of ABSS to rib 1: Proximity of the medial extremity of the ABSS terminus to the distal extremity of rib 1.

G0. Distance between the medial extremity of ABSS terminus and distal extremity of rib 1 is substantially less than half the length of the ABSS (*lavarackorum, dentata).*

G1. Distance between the medial extremity of ABSS terminus and distal extremity of rib 1 is substantially more than half the length of the ABSS (*oneiros*).

Character H – Medial extremity of ABSS relative to intersection of the nuchal, peripheral 1 and costal 1: This character is determined by observing the position of the medial extremity of ABSS terminus relative to a longitudinal line posterior from the sutural intersection of the nuchal, peripheral 1 and costal 1.

H0. The medial extremity of ABSS terminus lies almost directly posterior to the sutural intersection of the nuchal, peripheral 1 and costal 1 (*lavarackorum*).

H1. The medial extremity of ABSS terminus lies substantially lateral to a longitudinal line running posterior from the sutural intersection of the nuchal, peripheral 1 and costal 1 (*dentata*, *oneiros*).

Character I – Portion of the internal width of peripheral 2 occupied by the ABSS:

This character relates to the proportion of peripheral 2 occupied by the hyoplastron

suture with the carapace. It is measured by the shortest distance between the anterior edge of ABSS and the suture of peripherals 1 and 2.

I0. Distance between the anterior edge of ABSS and the suture of peripherals 1 and 2 is less than half the width of peripheral 2 (*dentata, lavarackorum).*

I1. Distance between closest anterior edge of ABSS and suture of peripherals 1 and 2 is equal to, or greater than half the interior width of peripheral 2 (*oneiros*).

Character J - ABSS-Nuchal: The position of the orthogonal level of the nuchal suture in relation to that of where the ABSS (base) first crosses the Peripheral 2-1st costal suture, pinned at the center point of that crossing on the suture.

J0. Line orthogonal contacts the nuchal suture at the lateral extremity of nuchal (*lavarackorum).*

J1. Line orthogonal contacts the nuchal suture at the posterior extremity of nuchal (*dentata, oneiros*).

Character K - ABSS Terminus-Base: An assessment of the size of the ABSS terminus relative to the size of the ABSS base at the point where peripheral 2 is immediately adjacent to the 1st costal.

K0. ABSS terminus is larger than base (*lavarackorum, dentata).*

K1. ABSS terminus is smaller than base (*oneiros*).

K2. ABSS terminus is subequal to base.

Character L – Shape of the medial extremity of ABSS:

L0. Medial extremity of ABSS has a rounded, lobed and bulbous shape (*dentata, lavarackorum).*

L1. Medial extremity of ABSS terminates with a tapered, finger-like projection (*oneiros*).

Character M - ABSS Terminus-Level: The position of the ABSS terminus at an orthogonal level relative to the distal-most portion of the 1st dorsal vertebra rib suture (rib one). In this condition the terminus lies in three conditions: anterior to, medial to, or posterior to the rib suture.

M0. Terminus lies anterior to rib one (*lavarackorum).*

M1. Terminus lies medial to rib one (*dentata, oneiros*).

M2. Terminus lies posterior to rib one.

Character N - Nuchal shape:

N0. Greatest width of the nuchal is at a point slightly posterior to half its length (*lavarackorum).*

N1. Greatest width of the nuchal is at a point substantially posterior to half its length (*dentata*, *oneiros*).

DISCUSSION

The distribution of character states for the nine additional thoracic skeletal characters assessed are described and illustrated for the three species of *Elseya* that are the focus of our investigation.

Character F - Nuchal-Peripheral 1: In the holotype of *E. lavarackorum* the width of the anterior border of the nuchal is subequal to that of the adjacent peripheral 1 (F2). In *E. dentata* the nuchal may be wider than (F0), or subequal (F2) to peripheral 1, while the nuchal is not as wide as peripheral 1 (F1) or subequal (F2) in *E. oneiros*.

Character G – Proximity of ABSS to rib 1: In the holotype of *E. lavarackorum* and in *E. dentata* the distance between the medial extremity of the ABSS terminus and distal extremity of rib 1 is substantially less than half the length of the ABSS (G0). In *E. oneiros* the distance is substantially greater than half the length of the ABSS (G1). As such, the condition in the holotype of *E. lavarackorum* is more similar to

that in *E. dentata* than it is to the condition in *E. oneiros*. The specimen of *E. dentata* QM J59277, examined and illustrated here (Plate 1), is the specimen illustrated as Fig 2C-D by Thomson *et al.* (1997). In their photograph rib 1 cannot be discerned and in their schematic drawing rib 1 is shown significantly shorter than it is in reality.

Character H – Medial extremity of ABSS relative to intersection of the nuchal, peripheral 1 and costal 1: In the holotype of *E. lavarackorum* the medial extremity of the ABSS is almost directly posterior to the sutural intersection of the nuchal, peripheral 1 and costal 1, and the condition in *E. dentata* QM J59277 is similar (H0). This state is incorrectly portrayed in the schematic drawing of the specimen of *E. dentata* (QM J59277) presented by Thomson *et al.* (1997: - Fig. 2D). In *E. dentata* QM J59279, a longitudinal line running posterior to the nuchal-peripheral 1-costal intersection is positioned further medially, relative to the ABSS terminus (H1), than it is in QM J59277. In *E. oneiros* the character also conforms to H1. Thus, while the position of the medial extremity of the ABSS relative to the sutural junction of the nuchal, costal 1 and peripheral 1 serves to distinguish *E. oneiros* from the fossil holotype of *E. lavarackorum*, its use in inferring relationship between the holotype of *E. lavarackorum* and *E. dentata* s.s. is equivocal.

Character I – Portion of the internal width of peripheral 2 occupied by the ABSS: In the holotype of *E. lavarackorum* the distance between the anterior edge of ABSS and the suture of peripherals 1 and 2 is less than half the interior width of peripheral 2 (I0). In *E. dentata* this distance is variable but in both QM J59277 and QM J59279 it is greater than half the interior width of peripheral 2 (I1). The extent to which the ABSS extends across peripheral 1-costal 1 junction in QM J59277 (Plates 1 & 2) is more extensive than presented in the schematic drawing of that specimen in Thomson *et al.* (1997: Fig 2D) and is more similar to that of the fossil holotype of *E. lavarackorum*. In *E. oneiros* the extent of the ABSS across the peripheral 2-costal 1 suture is minimal, so that the distance between the anterior edge of ABSS and the suture of peripherals 1 and 2 is also greater than half the interior width of peripheral 2 (I1). In *E. oneiros* QM J46284 the anterior peripherals are partially disarticulated from costal 1 and this may have affected this measurement. The *E. oneiros* specimen shown in Plate 3 is entire and the distance is substantially greater than it is in either the *E. lavarackorum* holotype or in E. *dentata*. Hence, while the extent to which the ABSS extends along the peripheral 2 - costal 1 suture amply serves to distinguish *E. oneiros* from the fossil holotype of *E. lavarackorum*, its use in inferring relationship between the holotype of *E. lavarackorum* and *E. dentata* s.s. is equivocal.

Character J - ABSS-Nuchal: The fossil holotype of *E. lavarackorum* (Plates 1 & 2) has the ABSS first contacting costal 1 ('pleural 1' of Thomson *et al.* (1997) – see above) at the conjunction of posterior peripheral 2 and anterior peripheral 3 (as in all known *Elseya*), but this conjunction occurs at the same level as the junction of the lateral-most point of the nuchal (J0), at a point substantially more anterior of the costal/ nuchal than it is in either *E. dentata* or *E. oneiros* (J1).

Character K - ABSS Terminus-Base: In the fossil holotype of *E. lavarackorum* the ABSS terminus is marginally larger than the base (K0), and as large or marginally larger in *E. dentata* (K0), whereas in *E. oneiros* the ABSS terminus is noticeably smaller than the base and ends truncated (K1).

Character L - Shape of the medial extremity of ABSS: In the fossil holotype of *E. lavarackorum* the ABSS on costal 1 has a distinct medial constriction and terminates in an inflated, rounded bulb (L0) (see also our discussion of character B above), and is the condition also seen in E. *dentata*, whereas in *E. oneiros* the medial portion of the ABSS on costal 1 has minimal to no medial constriction and terminates in a reduced, non-inflated, finger-like truncated end (L1).

Character M - ABSS Terminus-Level: In the fossil holotype of *E. lavarackorum* the ABSS terminus lies just anterior to the 1st rib suture (M0), but lies medial-posterior orthogonally in

TABLE 1. Distribution of the character states (A-E = Thomson *et al.* (1997); F-N = this study) for specimens of *Elseya lavarackorum*, *E. oneiros* and *E. dentata*. Boldened character states differ from that scored by Thomson *et al.* (1997).

Taxon & Specimen	Character State													
E. lavarackorum QM F24121	A1	B3	C1	D2	E0	F2	G0	H0	I0	K0	J0	L0	M0	N0
E. oneiros QM J46284	A1	B2	C1	D2	E0	F1	G1	H1	I1	K1	J1	L1	M1	N1
E. oneiros JC collection	A1	B2	C1	D2	E0	F2	G1	H1	I1	K1	J1	L1	M1	N1
E. dentata QM J59277	A1	B3	C1	D2	E0	F0	G0	H0	I1	K0	J1	L0	M1	N1
E. dentata QM J59279	A1	B3	C1	D2	E0	F2	G0	H1	I1	K0	J1	L0	M1	N1

E. *dentata*, and medially-anterior orthogonally in *E. oneiros* (M1).

Character N - Nuchal shape: The greatest width of the nuchal of the *E. lavarackorum* holotype is slightly posterior to a point halfway along the length of the bone (N0). In *E. dentata* and *E. oneiros* the greatest width of the nuchal is at a point significantly greater than halfway along the length of the bone (N1).

The results of our analysis of characters A - E utilised by Thomson *et al.* (1997) and of the additional characters F - N presented here are summarised in Table 1 above.

The fossil holotype of *E. lavarackorum* differs from *E. oneiros* in nine to ten of the 14 characters assessed and shares only four to five character states. The extent of these differences strongly supports the two as representing distinct species.

The fossil holotype of *E. lavarackorum* agrees with *E. dentata* (QM J59277; QM J59279) in nine of the characters assessed and differs in five character states. Of the skeletal character states shared between these two taxa, the morphology of the axillary bridge suture in the holotype of *E. lavarackorum* indicates it is best assigned to the subgenus *Elseya* based on the criteria of Thomson *et al.* (2015).

Of the fourteen character states, the two skeletal specimens of *E. oneiros* examined shared 13 character states and differed in one, and the two skeletal specimens of *E. dentata* shared 12 character states and differed in two, indicating that multiple specimens should be investigated where possible to assess for any additional intraspecific variation.

Two features of the anterior carapace rim of the *E. lavarackorum* holotype (Plate 5) that also mark it as distinct from *E. oneiros* are revisited here. In the holotype of *E. lavarackorum* the anterior carapace rim is much broader than that of either extant *E. dentata* or *E. oneiros* and it has a distinct nuchal emargination (the shallow concave notch at the midpoint of the anterior carapace edge, previously assessed by Joseph-Ouni *et al.* 2020) that is present in some specimens of *Elseya dentata*, but which was not observed in any of the specimens of *E. oneiros* listed as examined by Joseph-Ouni *et al.* (2020) (11 in Appendix B, and eight additional specimens listed).

The presence of nuchal emargination in the holotype of *E. lavarackorum* was also addressed by Thomson *et al.* (1997) in support of a close (conspecific) relationship between the fossil *Emydura lavarackorum* and the extant form of *Elseya* from the Nicholson River, as follows:

> 'A significant feature of *Emydura lavarackorum*, though difficult to quantify, was an indentation of the carapace margin in the area of the cervical cleft and first marginal scutes. This feature is held in common with turtles in the *Elseya latisternum* group and *Pseudemydura*, is variable among the Queensland forms of *Elseya dentata*, and never present in the Northern Territory and New Guinea forms

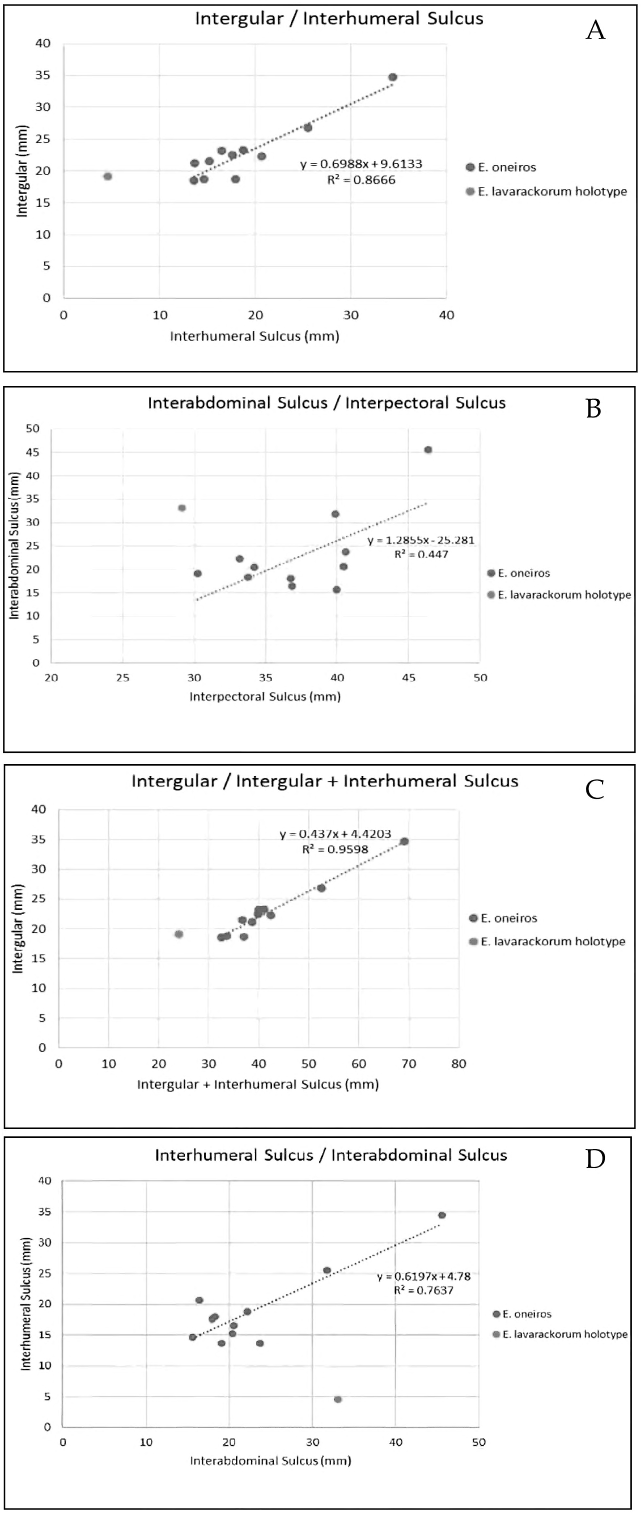

FIG. 1. *Elseya oneiros* is readily diagnosed from *E. lavarackorum* by the intergular length / interhumeral sulcus length ratio (d) (1.01-1.55 for *E. oneiros* n =11 vs 4.17 for *E. lavarackorum* holotype); the interabdominal sulcus length / interpectoral sulcus length ratio (e) (.39-.98 in *E. oneiros* n= 11 vs 1.13 in *E. lavarackorum* holotype); the intergular sulcus length / intergular + interhumeral sulcus length ratio (e) (0.50-0.58 in *E. oneiros* n= 11 vs 0.80 in *E. lavarackorum* holotype); the interhumeral sulcus length / interabdominal sulcus length ratio (e) (0.58 – 1.26 in *E. oneiros* n= 11 vs 0.14 in *E. lavarackorum* holotype). It is diagnosed from the northern Australian *Elseya dentata* group by the interhumeral sulcus length / interabdominal sulcus length ratio (0.58-1.26 in *E. oneiros* vs 0.11-0.20 in the *E. dentata* group) and from the Queensland *Elseya (Pelocomastes)* group by the genetic data presented in Georges & Adams, 1996 and Todd *et al.,* 2014.

FIGS 2A-D. **A)** Scatterplot showing the intergular length / interhumeral sulcus length ratio for *E. oneiros* and *E. lavarackorum*. **B)** Scatterplot showing the interabdominal sulcus length / interpectoral sulcus length ratio for *E. oneiros* and *E. lavarackorum*. **C)** Scatterplot showing the intergular sulcus length / intergular + interhumeral sulcus length ratio for *E. oneiros* and *E. lavarackorum*. **D)** Scatterplot showing the interhumeral sulcus length / interabdominal sulcus length ratio for *E. oneiros* and *E. lavarackorum*.

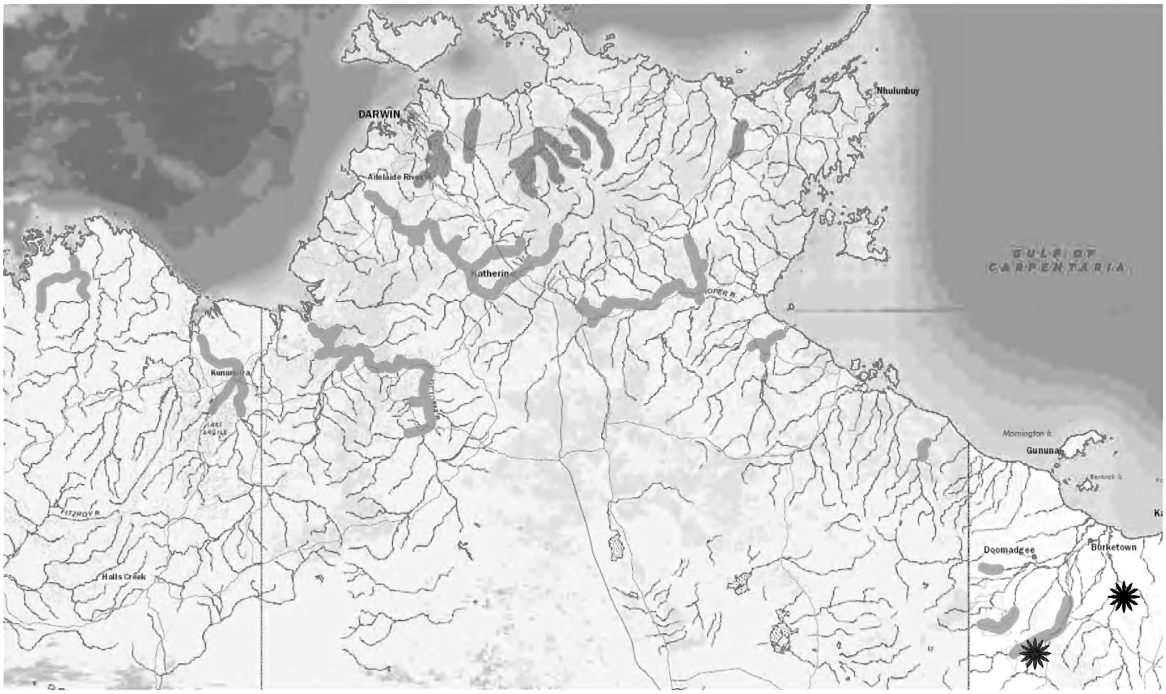

FIG. 3. Distribution of *Elseya* species in northern Australia: the species *E. dentata* (red) and *E. flaviventralis* (yellow) in the extant subgenus *Elseya*; the Pleistocene fossils, *E. lavarackorum* (brown star) and *E.* sp. Leichhardt (black stars); and *E. oneiros* (purple) in the extant subgenus *Pelocomastes*. Extant species distributions are restricted to confirmed museum and/or photographic identification with the exception of the populations of Western Australia and the Roper and Limmen rivers (Northern Territory which are under investigation (also see TTWG 2021), and also include field identifications by J. Cann and A. Freeman; distributions assumed to eventually be broader with further data. *E. (E.)* sp. Leichhardt refers to a new Pleistocene fossil species (description *in. prep.* by A. White). Base map © State of Queensland 2020.

> of *Elseya dentata* nor in *Elusor, Rheodytes* and *Emydura*. Although not considered a useful character at generic level, we will use it in combination with other similarities to establish a close relationship between the fossil *Emydura lavarackorum* and an extant form of *Elseya* from the Nicholson River.'

We agree that nuchal emargination is difficult to quantify (although it has been used repeatedly as a key character in the diagnosability of fossil chelonian species - MJO, AW pers. obs., see also Joyce and Lyson (2015) and Maniel and de la Fuente (2016). However, our observations on this feature (Joseph-Ouni *et al.*, 2020) are not in concordance with those presented by Thomson *et al.* (1997). We do not regard it as providing evidence in support of a close relationship between the fossil holotype of *E. lavarackorum* and the extant *Elseya* from the Nicholson River, *E. oneiros* (Plate 5). The observation offered by Thomson *et al.* (1997) that the nuchal emargination is "never present in the Northern Territory and New Guinea forms of *Elseya dentata*" is incorrect for the Northern Territory, as illustrated for *E. dentata* by Joseph-Ouni *et al.* (2020). As nuchal emargination does indeed occur invariably in *E. dentata*, we point to this shared occurrence with the holotype of *E. lavarackorum* as indicative of a closer relationship with that extant taxon, not with *E. oneiros*. As *E. dentata* does not occur in New Guinea, our assumption for the 'New Guinea' form is in reference to the

New Guinea endemic *E. branderhorsti*, and we confirm here that nuchal emargination is absent in that species (pers. obs. MJO).

Lastly, we note that the TTWG (2021), citing an unpublished, private report by Georges *et al.* (2021), extended the range of *E. oneiros* (under the nomen *E. lavarackorum*) into the upper reaches of the Roper River, Northern Territory. Additionally, that same report concluded that the *Elseya dentata* population of the Roper and Limmen rivers (the two species being found in microsympatry in the Roper) constituted a distinct species based on genetic analysis. The taxonomy of *Elseya* species in northern Australia is currently under investigation (Joseph-Ouni *et al.*, in prep.), and a distribution map of the current taxonomy of *Elseya* in northern Australia (Figure 3) is presented here pending further data.

CONCLUSION

The diagnostic scute characters presented in Joseph-Ouni *et al.* (2020) in combination with the differentiation in skeletal characters presented here confirm the distinction made between the fossil holotype of *E. lavarackorum* and *E. oneiros*, and that the two species are not conspecific. We again validate *Elseya* (*Pelocomastes*) *oneiros* as the only extant *Elseya* occurring in the Nicholson-Gregory drainages, as represented by the holotype (QMJ 47908, an adult male collected from Elizabeth Gorge, Bowthorn Station, Queensland, Australia on the 23 April 1988) lodged in the herpetological collection of the Queensland Museum (Plate 6).

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